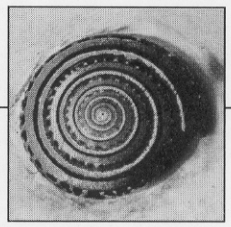
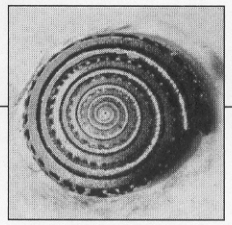


300 SERIES

UNIVERSAL
WAVEFORM
GENERATORS

Operator's Manual

WAVETEK datron



300 SERIES UNIVERSAL WAVEFORM GENERATORS

Operator's Manual

Models 301 & 302 – 300 MS/s SINGLE / DUAL ARBITRARY WAVEFORM GENERATORS

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DECLARATION OF CONFORMITY

We: Wavetek-Datron Inc.
Instrument Division
9045 Balboa Avenue
San Diego, CA 92123

declare, that the 50 MHz Pulse/Function Generators

Model 301 and Model 302

meet the intent of Directive 89/336/EEC for Electromagnetic Compatibility and complies with the requirements of the Low Voltage Directive 73/23/EEC. Compliance was demonstrated to the following specifications as listed in the official Journal of the European Communities:

Safety:
EN 61010-1
IEC 1010-1 (1990) + Amendment 1 (1992)

EMC:
EN 50081-1 Emissions:
EN 55022 - Radiated, Class B
EN 55022 - Conducted, Class B
EN 50082-1 Immunity:
IEC 801-2 (1991) - Electrostatic Discharge
IEC 801-3 / ENV50140 (1993) - RF Radiated
IEC 801-4 (1991) - Fast Transients

Model 301 and Model 302 were tested in typical configuration.

SAFETY PRECAUTIONS

Protect yourself. Follow these precautions:

- Don’t bypass the power cord’s ground lead with two-wire extension cords or plug adapters.
- Don’t disconnect the green and yellow safety-earth-ground wire that connects the ground lug of the power receptacle to the chassis ground terminal (marked with or
- Don’t plug in the power cord until directed to by the installation instructions.
- Don’t repair the instrument unless you are qualified electronics technician and know how to work with hazardous voltages.
- Pay attention to the **WARNING** statements. They point out situations that can cause injury or death.
- Pay attention to the **CAUTION** statements. They point out situations that can cause equipment damage.

The American National Standard Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60 VDC are present. A good safety practice is to expect that hazardous voltage is present in any unknown circuit before touching or disconnecting the line cord. Before operating this instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables and test leads for possible wear, cracks, or breaks before each use.

For maximum safety, do not touch the product, test cables, or any other of the instrument parts while power is applied to the circuit under test. **ALWAYS** remove power from the entire test system before connecting cables or jumpers, or making internal changes. Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always keep dry hands while handling the instrument. If you are using test fixtures, keep the lid closed while power is applied to the device under test. Safe operation requires that the instrument covers be closed at all times during operation.

Carefully read the Safety Precautions instructions that are supplied with your instrument. Instruments, cables, leads or cords should not be connected to humans. Before performing any maintenance, disconnect the line cord and all test cables.

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Getting Started

What's In This Chapter

This chapter contains a general description of the Model 301/302 Arbitrary Waveform Generator and an overall functional description of the instrument. It lists and describes various options available for this model. It also describes the front panel connectors and indicators.

This manual provides description of all features and options available with the instruments; however, some items described in the following paragraphs may not be installed in your instrument. If you purchased Model 301, ignore all references in this manual to Channel B.

Figure 1-1, Model 301/302

Introduction

A detailed functional description is given following the general description of the features, functions, and options available with the Model 301/302.

Model 301 is a single-channel Arbitrary Waveform Generator. Model 302 is a dual-channel, Arbitrary Waveform Generator. It is a high performance waveform generator that combines two separate and powerful channels in one package.

Each channel has its own waveform generator, as well as, amplitude, offset, and AM controls. The two channels share common sample clock source therefore, inter-channel phase relationship can be controlled tightly.

Both channels generate waveforms from one sample clock source and start from one trigger source, ensuring that all waveforms are fully synchronized in terms of frequency and start phase of the output waveforms. Further control over start phase is provided in cases where phase offset between the two channels is required.

Model 301/302 is completely digital. There are no analog functions resident in its hardware circuits. Data has to be downloaded to the instrument for it to start generating waveforms. The instrument can generate a few standard functions such as sine wave, triangular wave and square wave. Each time that a standard function is required, the instrument has to calculate its coordinates and place them in the waveform memory. Therefore, every time a standard function is recalled, minimal time is required for the controller to compute the function and load its data to the waveform memory.

The frequency accuracy of the output waveform is determined by the clock reference. The internal reference oscillator provides 1 ppm accuracy and stability over time and temperature. If higher accuracy and/or stability are required, The user may connect his own sample clock generator to a front panel input. Frequency is programmed with 7 digits, so using an external sample clock source is recommended if you need better resolution, accuracy and stability.

Output amplitude for each channel may be programmed separately within the range of 20 mV to 10 Vp-p into an open circuit, or 10 mV to 5 V into 50□. Offset is applied directly at the output connector therefore, it is not attenuated with the output signal. This feature allows generation of low-level signals with very high offset ratio. For example, it is possible to program 50 mV amplitude with 2 V offset. Amplitude and offsets are programmed with 4 digits of resolution.

Besides its normal continuous mode, the Model 301/302 responds to a variety of trigger sources. The output waveform may be gated,

triggered, or may generate a counted burst of waveforms. A built-in trigger generator, having a programmable period can be used as a replacement of an external trigger source.

The Model 301/302 generates arbitrary waveforms with 12 bits of vertical resolution. Any waveform it generates must first be downloaded to waveform memory.

The arbitrary waveform memory is a bank of 12-bit words. Each word represents a point on the horizontal waveform scale. Each word has a horizontal address that can range from 0 to 4,191,280 (16,777,720) with the 16 Meg option installed) and a vertical address that can range from -2048 to +2047 (12 bits). Using a high speed clocking circuit, the digital contents of the arbitrary waveform memory are extracted and routed to the Digital to Analog Converter (DAC). The DAC converts the digital data to an analog signal, and the output amplifier completes the task by amplifying or attenuating the signal at the output connector.

There is no need to use the complete memory every time an arbitrary waveform is generated. Waveform memory can be divided into up to 4096 smaller segments and different waveforms can be loaded into each segment. The various segments may then be loaded into a sequence table to generate long and complex waveforms. The sequence table can link up to 4096 segments, while each segment can loop up to 1 million times. The model 301/302 can store up to 16 different sequence tables, then use these sequences for generating a sequence of these 16 sequences.

The instrument must be used in conjunction with a host computer. All of its functions, modes and parameters are fully programmable using SCPI commands and syntax. There are three ways to program the Model 301/302, the first being low-level programming of each individual parameter using SCPI commands. The second alternative is to use WaveWiz for high-level programming. WaveWiz is a software package supplied with the 301/302 that simulates a mechanical front panel. It has all the necessary push buttons, displays and dials to operate the Model 301/302 in a similar way to using a bench-top instrument. The third way to program the 301/302 is by using either the LabVIEW driver.

The Model 301/302 must be programmed to generate waveforms. Therefore, it is recommended that the user becomes familiar with its basic features, functions and programming concepts as described in this and the following chapters.

Options

There is only one option available with the model 301/302. This option expands the waveform memory from 4 Meg to 16 Meg. The instrument must be ordered with the 16 Meg option installed, it cannot

be retrofitted later.

The 4 Meg option designates the memory size supplied with the standard Model 301/302. With the standard memory size, 4,191,280 point waveforms can be programmed. The 16 Meg option designate an instrument supplied with memory expansions. With the 16 Meg memory expansion, 16,776120 point waveforms can be programmed for each channel.

Safety Considerations

The Model 301/302 has been manufactured according to international safety standards. The instrument meets EN61010, VDE 0411/03.81 and UL 1244 standards for safety of commercial electronic measuring and test equipment for instruments with an exposed metal chassis that is directly connected to earth via the chassis power supply cable.

WARNING

Do not remove instrument covers when operating or when the chassis power cord is connected to the mains.

Any adjustment, maintenance and repair of an opened, powered-on instrument should be avoided as much as possible, but when necessary, should be carried out only by a skilled person who is aware of the hazard involved.

Supplied Accessories

The instrument is supplied with an Instruction Manual. The manual includes a disk with WaveWiz for Windows 95/98/NT. A Service Manual is available upon request.

Specifications

Instrument specifications are listed in Appendix A. These specifications are the performance standards or limits against which the instrument is tested. Specifications apply under the following conditions: output terminated into 50Ω after 30 minutes of warm up time, and within a temperature range of 20°C to 30°C. Specifications outside this range are degraded by 0.1% per °C.

Functional Description

A detailed functional description is given in the following paragraphs. The description is divided into logical groups: input and output connectors, operating modes, output type, output state, filters, synchronization, and front panel indicators.

Input and Output Connectors

The Model 301/302 has 6 or 9 BNC connectors on its front panel: one main output and one auxiliary output per channel, one SYNC output, one AM input per channel, one trigger input and one sample clock input.

Main Output - Channel A

The channel A output connector outputs fixed (standard) waveforms to 150 MHz, user (arbitrary) and sequenced waveforms with sampling clock to 300 MS/s. Output impedance is 50Ω, that is, the cable connected to this output should be terminated with 50Ω. Output amplitude accuracy is calibrated when connected to a 50Ω load. The output amplitude is doubled when the output impedance is above 1 MΩ.

Auxiliary Output - Channel A (I)

The Auxiliary output connector outputs exactly the same waveforms as the Main output connector. The only difference is that the low output has fixed amplitude of 1 Vp-p into 50Ω

Main Output - Channel B

The Channel B output connector outputs fixed (standard) waveforms to 150 MHz, user (arbitrary) and sequenced waveforms with sampling clock to 300 MS/s. Output impedance is 50Ω, that is, the cable connected to this output should be terminated with 50Ω. Output amplitude accuracy is calibrated when connected to a 50Ω load. The output amplitude is doubled when the output impedance is above 1 MΩ.

Auxiliary Output - Channel B (Q)

The Channel B Auxiliary output connector outputs exactly the same waveforms as the Main output connector. The only difference is that the low output has fixed amplitude of 1 Vp-p into 50Ω

SYNC Output

The SYNC output generates a single TTL pulse for synchronizing other instruments (i.e., an oscilloscope) to the output waveform. The SYNC signal always appears at a fixed point relative to the waveform. The location of the signal along the waveform is programmable.

Trigger Input

In general, the trigger input accepts signals that stimulate the output waveforms. The trigger input is inactive when the generator is in

continuous operating mode. When placed in trigger, gated or burst mode, the trigger input is made active and waits for the right condition to trigger the instrument. In trigger and burst modes, the trigger input is edge sensitive, i.e., it senses transitions from high to low or from low to high to trigger the Model 301/302. The direction of the transition is programmable. In gated mode, the trigger input is level sensitive, i.e., the Model 301/302 is gated when the logic level is high and idle when the level is logic low. Trigger level for this input is programmable.

The trigger input is common to both channels. Therefore, if the model 301/302 is placed in trigger mode, both channels share the same mode and the trigger input causes both channels to start generating waveforms at the same time.

Phase relationship between channels is tightly controlled in trigger mode. You should expect that both channels will start generating waveforms with exactly the same start phase. Further control over phase offset between channels is also provided. Applying a phase offset between the channels is described later in this manual.

AM Input – Channel A

The channel A AM input accepts signals that amplitude modulate the channel A signal. The Channel A AM input becomes active only when the AM function is selected.

AM Input – Channel B

The channel B AM input accepts signals that amplitude modulate the channel B signal. The Channel B AM input becomes active only when the AM function is selected.

Sample Clock Input

The external clock input is available for those applications requiring synchronization to one sample clock source. Normally, this input is disabled. When enabled, the clock at this input replaces the internal clock generator and the 301/302 generates waveforms with the sample clock at the Sample Clock input.

Operating Modes

The 301/302 can be programmed to operate in one of four operating modes: continuous, triggered, gated and counted burst. These modes are described below.

As was discussed above, both channels are placed simultaneously in triggered mode. All channels will start generating waveforms when a valid trigger signal is received at the trigger input. Both waveforms will start and complete at exactly the same instance.

Continuous Mode

In normal continuous mode, the selected waveform is generated continuously at the selected frequency, amplitude and offset.

Triggered Mode

In triggered mode, the Model 301/302 circuits are armed to generate one output waveform. The trigger circuit is sensitive to transitions at the trigger input. Select between positive or negative transitions to trigger the instrument. You may also program the trigger level to the desired threshold level. When triggered, the generator outputs one waveform cycle and remains idle at the last point of the waveform. The Model 301/302 can be armed to receive a trigger signal from a front panel connector or from a GPIB command or from an internal, programmable trigger generator.

The trigger signal, whether it comes from the front panel or from the GPIB interface, has to pass through some electrical circuits. These circuits cause a small delay known as system delay. System delay cannot be eliminated completely. It is, however, minimized in the Model 301/302 to approximately 100 ns maximum. System delay is a factor that must be considered when applying a trigger signal. It defines how long it will take from a valid trigger edge to the moment that the output reacts.

Burst Mode

The burst mode is an extension of the triggered mode where the Model 301/302 can be programmed to output a pre-determined number of waveforms. The source to trigger the counted burst cycle can be selected from a front panel connector, GPIB trigger or from the built-in trigger generator.

Gated Mode

In gated mode, the Model 301/302 circuits are armed to generate output waveforms as long as a gating signal is present. Unlike the triggered mode, the gated mode is level sensitive. When the gating signal goes low, the waveform at the output connector is first completed and the output goes to an idle state. The idle amplitude level, after the gating signal goes low, is the last point on the waveform.

Output Type

The Model 301/302 can output three types of waveforms: standard (Fixed), arbitrary (User) and sequenced waveforms. Different waveform types may be assigned to each channel. Description of the various waveform types that the Model 301/302 can generate is given below.

Standard (Fixed) Waveforms

The Model 301/302 generates waveforms from a memory that has to be loaded before the instrument can generate waveforms. There are a number of memory options that are available with the instrument. Memory option must be specified at the time of purchase. Field upgrade of memory options is not available. On power up, the waveform memory has no specific data. The sine waveform, being the default waveform on power on, is computed and loaded to the waveform memory as part of the reset procedure. From this moment on, every time that another standard waveform is selected, it is being computed and loaded to the waveform memory.

Waveforms are written from the same start address. Therefore, every time that a new waveform is selected, there is some minimal time for the processor to compute and download the data to the memory.

The Model 301/302 can be programmed to output one of nine standard waveform shapes: sine, triangle, square, pulse/ramp, sine(x)/x pulse, gaussian pulse, rising/decaying exponential pulse, noise and dc. There are some parameters associated with each waveform, which modify the shape of the waveform to better suit your needs. For example, different start phase for the sine waveform can be programmed for each channel to create phase offsets between the two output channels.

Arbitrary (User) Waveforms

The arbitrary waveform memory is capable of storing one or more user-defined waveforms. As was discussed before, and unless ordered differently, the Model 301/302 is supplied with 4 Meg memory banks with channels 1 and 2. With the 16 Meg option, there are up to 16 Meg points that can be allocated to one single waveform. On the other hand, there is no need to use the entire memory for only one waveform. The memory can be divided into smaller segments and loaded with different waveforms. The instrument can be programmed to output one segment at a time.

Loading data to arbitrary waveform memory can be a time-consuming task, especially if all 16 Meg points are loaded in one shot. The Model 301/302 utilizes a DMA concept that speeds data transfer from host computer to the instrument. In this mode, the memory bank is disconnected from the CPU circuit and re-routed to the GPIB bus for direct memory accessing by the host computer.

There are two separate memory banks for each channel that can be loaded with different waveforms. Channels are not limited by the number of segments and by the shape of the waveforms.

Sequenced Waveforms

The sequence generator is a very powerful tool that lets you link and loop segments in any way you desire. As a simple example of a sequenced waveform, look at Figures 1-1a through 1-1c. The waveforms shown in these figures were placed in memory segments 1, 2 and 3, respectively. The sequence generator takes these three waveforms links and loops them in a predefined order to generate the waveform shown in Figure 1-1d.

The sequence circuit is useful for generating long waveforms with repeated sections. The repeated waveform has to be programmed once and the repeater loops on this segment as many times as selected. When in sequenced mode, there is no loss of time between linked or looped segments.

The Model 301/302 can store up to 16 different sequences, then use these sequences in a macro sequence that can sequence all 16 sequences. The sequence generator, as well as, the macro sequence generator is common to both channels.

Sequence tables must be loaded to the generator before sequenced waveforms can be generated. The data for the sequence table is first prepared on external platforms, then downloaded to the generator. Figure 1-5 shows an example how to define a sequence using WaveWiz.

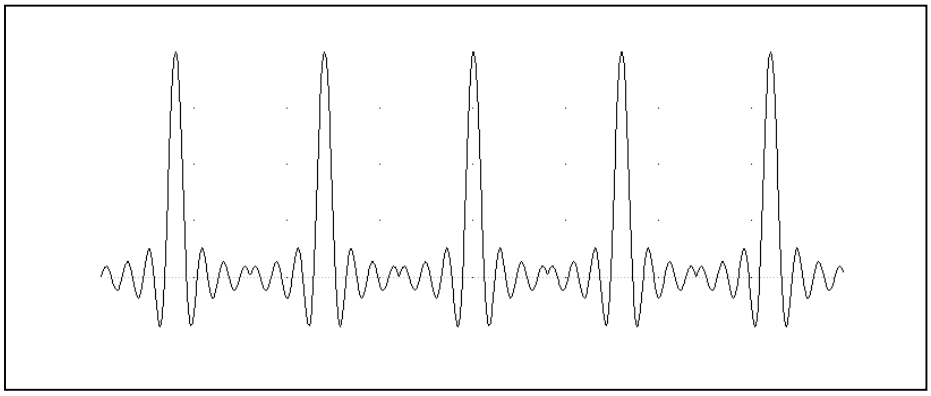

Figure 1.1a , Segment 1 – Sin (x)/x Waveform

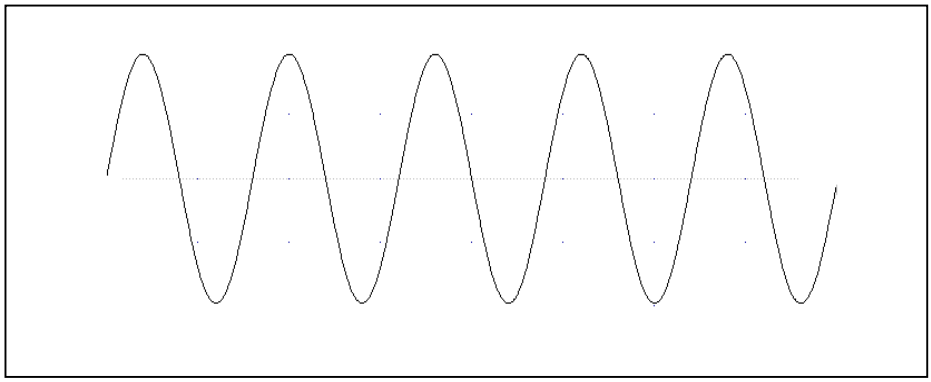

Figure 1.1b. Segment 2 – Sine Waveform

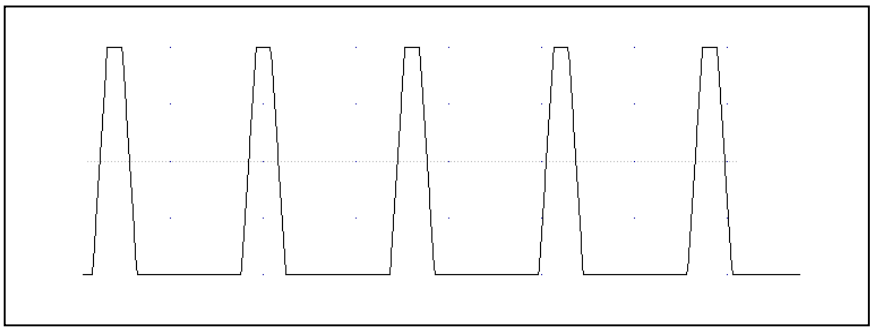

Figure 1.1c Segment 3 – Pulse Waveform

The following sequence was made of segment 2 repeated twice, segment 1 repeated four times, and segment 3 repeated two times.

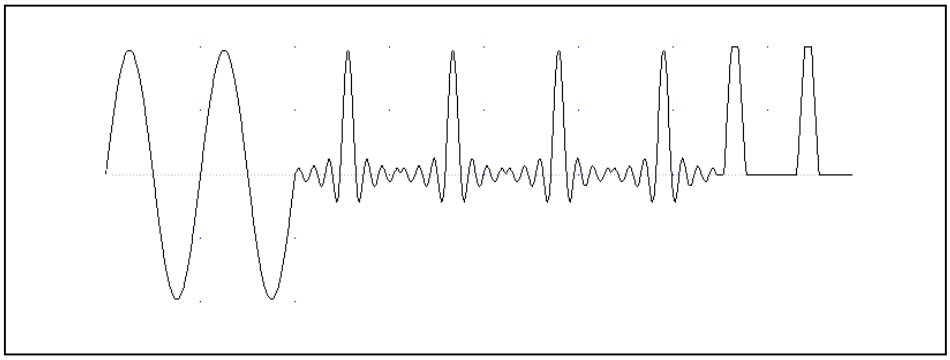

Figure 1.1d Sequenced Waveforms

Output State

The main outputs can be turned on or off. The internal circuit is disconnected from the output connector by a mechanical switch (relay). This feature is useful for connecting the main outputs to an analog bus. For safety reasons, when power is first applied to the chassis, the main output is always off.

Filters

Ten filters are built into the Model 301/302, five for each channel. These filters are available for use in various applications such as the creation of high frequency sine waves and removing the staircase effect from waveforms that are generated with high frequency clock rates.

Front Panel Indicators

There are five LEDs on the front panel. The POWER LED (Red) illuminates at power-up and remains on until the Model 301/302 has been turned off.

The ACCESS LED (Amber) illuminates each time a command has been received by the Model 301/302. This light remains on during DMA data transfer.

The REMOTE light turns on the first time the GPIB remote enable line is true. GTL (go to local) command or power down turn this light off.

When the output state is on, the OUTPUT LED (Green) light illuminates. There are two LEDs, one for each channel. Note that the LEDs are part of the Main output. There is no ON indication for the Auxiliary outputs.

Programming The Model 301/302

The Model 301/302 has no controls on its front panel. Instrument functions, parameters, and modes can only be accessed through GPIB or RS232 commands. There are a number of ways to “talk” to the instrument. They all require that an appropriate software driver be installed in the host computer. The rest is a matter of practice and knowledge of the language in use. There are other system considerations like address selection that have to be settled before programming the instrument. These topics are discussed in later chapters.

Low level programming of the Model 301/302 is accomplished using SCPI (Standard Commands for Programmable Instruments) language. Programming aspects are covered in Chapters 3 and 4.

Supplied with the 301/2 is a PC software package called WaveWiz. This provides a user interface with a familiar windows interface which allows the user to interact with and control the 301/2 directly. Details of how to use WaveWiz are supplied in the following pages.

CONFIGURING The INSTRUMENT

Installation Overview

This chapter contains information and instructions necessary to prepare the Model 301/302 for operation. Details are provided for initial inspection, grounding requirements, repackaging instructions for storage or shipment, address selection and installation information.

Unpacking and Initial Inspection

Unpacking and handling of the generator requires normal precautions and procedures applicable to handling of sensitive electronic equipment. The contents of all shipping containers should be checked for included accessories and certified against the packing slip to determine that the shipment is complete.

Safety Precautions

The following safety precautions should be observed before using this product and associated computer. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified persons who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product.

WARNING

For maximum safety, do not touch the product, test cables, or any other instrument parts while power is applied to the circuit under test. ALWAYS remove power from the entire test system before connecting cables or jumpers, installing or removing cards from the computer, or making internal changes such as changing the GPIB address.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always keep your hands dry while handling the instrument.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cables, connector jacks, or test fixtures. The American National Standard Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak,

or 60VDC are present. Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables and test leads for possible wear, cracks, or breaks before each use.

For maximum safety, do not touch the product, test cables or any other of the instrument parts while power is applied to the circuit under test. ALWAYS remove power from the entire test system before connecting cables or jumpers, installing or removing cards from the computer or making internal changes, such as changing card address.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always keep dry hands while handling the instrument.

When using test fixtures, keep the lid closed while power is applied to the device under test. Carefully read the “Safety Precautions” instructions that are supplied with your test fixtures.

Before performing any maintenance, disconnect the line cord and all test cables. Only qualified service personnel should perform maintenance.

If you have no past experience in computer servicing, we strongly recommend that installation and initial tests on the instrument be done by your computer dealer or by the factory itself

Performance Checks

The instrument has been inspected for mechanical and electrical performance before shipment from the factory. It is free of physical defects and in perfect electrical order.

Power Requirements

The function generator may be operated from any one of the following sources: a. 103.5 to 126.5 Volts (115 Volts, NOMINAL) b. 207 to 253 Volts (230 Volts, NOMINAL).

The instrument operates over the power mains frequency range of 48 to 63Hz. Always verify that the operating power mains voltage is the same as that specified on the rear panel voltage selector switch.

The Model 301/302 should be operated from a power source with its neutral at or near ground (earth potential). The instrument is not intended for operation from two phases of a multi-phase ac system or across the legs of a single-phase, three-wire ac power system. Crest factor (ratio of peak voltage to rms.) should be typically within the range of 1.3 to 1.6 at 10% of the nominal rms. mains voltage.

Grounding Requirements

To ensure the safety of operating personnel, the U.S. O.S.H.A. (Occupational Safety and Health) requirement and good engineering practice mandate that the instrument panel and enclosure be "earth" grounded. The long offset pin on the male end of the power cable carries the ground wire to the long pin of the Euro connector (DIN standard) receptacle on the rear panel of the instrument.

To preserve the safety protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green lead on the adapter to an "earth" ground.

WARNING

Do not attempt to float the output from ground as it may damage the Model 301/302 and your equipment.

CAUTION

To avoid operator shock hazard do not exceed the power mains voltage frequency rating which limits the leakage current between case and power mains. Never expose the instrument to rain, excessive moisture, or condensation.

Long Term Storage or Repackaging For Shipment

If the instrument is to be stored for a long period of time or shipped immediately, proceed as directed below. If you have any questions, contact your local Wavetek-Datron Representative or the Wavetek-Datron Customer Service Department.

1. Repack the instrument using the wrappings, packing material and accessories originally shipped with the unit. If the original container is not available, purchase replacement materials.

2. Be sure the carton is well sealed with strong tape or metal straps.

3. Mark the carton with the model and serial number. If it is to be shipped, show sending and return address on two sides of the box.

NOTE

If the instrument is to be shipped to Wavetek-Datron for calibration or repair, attach a tag to the instrument identifying the owner. Note the problem, symptoms, and service or repair

desired. Record the model and serial number of the instrument. Show the work authorization order as well as the date and method of shipment. ALWAYS OBTAIN A RETURN AUTHORIZATION NUMBER FROM THE FACTORY BEFORE SHIPPING THE INSTRUMENT TO Wavetek-Datron.

Preparation For Use

Preparation for use includes removing the instrument from the container box, selecting the required logical address and connecting the instrument to the power line and to a host computer.

Logical Address Selection

The GPIB Resource Manager identifies modules in the system by the module's address. GPIB logical addresses can range from 0 to 31, however, addresses 1 to 31 **only** are reserved for GPIB instruments. Logical address 0 is reserved for the GPIB controller.

To change the logical address, open the top cover and use the 8-position DIP switch accessible from the top side of the generator near the rear end of the case (switch S1). Figure 2-1 shows the location of the logical address switch. The switches are marked with numbers 1 to 8. The Model 301/302 uses binary values (2^0 to 2^7) to set the logical address using the active low address switch. A switch is active when its arm is placed in the ON position. Wavetek-Datron ships the Model 301/302 with logical address 2.

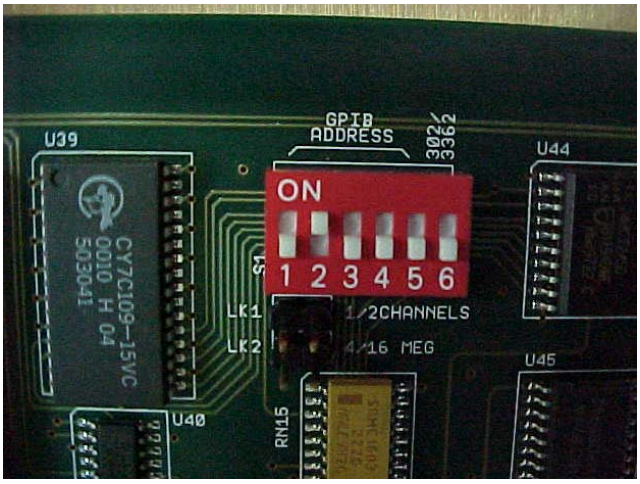

Figure 2.1 Setting Logical Address

Installation

The instrument is fully solid state and dissipates only a small amount of power. No special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds 40°C, when the relative humidity exceeds 80% or condensation appears anywhere on the instrument.

Avoid operating the instrument close to strong magnetic fields, which may be found near high power equipment such as motors, pumps, solenoids or high power cables. Use care when rack mounting to locate the instrument away from sources of excessive heat or magnetic fields. Always leave 4 cm (1.5 inches) of ventilation space on all sides of the instrument.

Bench Operation

The Model 301/302 is shipped with plastic feet, tilt stand in place and ready for use as a bench or portable instrument

Rack Mounting

The instrument may be rack mounted in a standard 19 inch rack. Rack mounting ears are part of the 302 case. Telescopic rack mounting slides are also available.

USING The INSTRUMENT.

Overview

This chapter contains information about how to operate the Model 301/302. The Model 301/302 must be programmed to turn on functions, change parameters and configure various operating modes. The Model 301/302 is supplied with WaveWiz, a PC based software package with a graphical user interface to allow users to program all of the functions directly. LabView drivers and a set of SCPI commands are available for more experienced programmers. SCPI (standard commands for programmable instruments) commands for the Model 301/302 are listed in Table 4-1. This manual provides information on low-level programming using SCPI commands and using WaveWiz to control the same functions.

The following paragraphs describe the various modes of operation and give examples of how to program the Model 301/302. The manual is organized by instrument function and instructions are given in each paragraph on how to use the function from both SCPI and WaveWiz.

Inter-Channel Dependency

The Model 302 has two output channels. Although this is a two-channel instrument, most of the commands that set parameters and functions are common for both channels. For example, sample clock and trigger modes can not be set separately for each channel. On the other hand, you may program each channel to have different function shape, amplitude and offset. Table 3-1 lists the function and parameters and their related Inter-channel dependency.

Output Termination

During use, output connectors must be properly terminated to minimize signal reflection or power loss due to impedance mismatch. Proper termination is also required for an accurate amplitude level at the main output connector. Use 50Ω cables and terminate the main and SYNC cables with terminating resistors. Always place the 50Ω termination at the far end of the cables.

Input / Output Protection

The Model 301/302 provides protection for internal circuitry connected to input and output connectors. Refer to the specifications in Appendix A to determine the level of protection associated with each input or output connector.

Power On/Reset Defaults

At Power On or as a result of a software reset, the instrument defaults to some factory pre-selected conditions. A complete list of all parameters, their default values, as well as their maximum and minimum values is given in Chapter 4.

Use the following command to place the instrument in its default state:

```
RESet;
```

Using the IEEE-STD-488.2 common command *RST will have the same result. The table below shows the instrument settings after this command is executed.

Function / Parameter	Default	Inter-Channel Dependency
Output State:	Off	Separate
Operating Mode:	Continuous	Common
SYNC State:	Off	Common
SYNC Out Position:	Wave Start	Common
Output Function:	Standard	Separate
Output Function Shape:	Sine	Separate
Standard Wave Frequency:	1 MHz	Common
User Wave Sample Clock:	10 MHz	Common
Amplitude:	2 V	Separate
Offset:	0 V	Separate
Filter State:	Off	Separate
Filter Type:	Auto	Separate
Trigger Slope:	Positive	Common
Trigger Level:	1.6 V	Common
Internal Trigger Period:	100 μs	Common
AM State:	Off	Separate
DMA State:	Off	Separate

*Figure 3.1 Default Conditions After Power On or After *RST*

Programming the 301/302

When writing low level code to operate the Model 301/302, follow the instructions in this chapter to understand the meaning and response that each command generates. Examples contained in the following paragraphs show basic techniques of how to program output waveforms.

Example 1

The following example programs the Model 301/302 to turn on the main outputs and program the waveform frequency to 20 MHz. Then, program channel A to output square waveform with an amplitude of 2 V and offset of 0.5V, and program channel B to output triangular waveform with an amplitude of 1 V and offset of 0.5 V.

/* Reset the Model 301/302 to its default condition as listed in Table 3-1. */

:RESet;

/* Change the output waveform to square. Note that there is no need to use the FUNC:MODE command as the default value after RESet is FIXed. */

:FUNCtion:SHAPe SQUare;

/* Change the frequency to 20 MHz. Note that frequency setting is common for both channels. */

:FREQuency 20e6;

/* Change channel A amplitude to 2 V and the offset to 0.5 V. */

:VOLTage 2;

:VOLTage: OFFSet 0.5;

Note that output peak voltage may never exceed ±2.5 V. Amplitude and offset may be set freely within a 5 V window, as long as the following limits are kept:

$$| \text{offset} | + (Vp\text{-}p \div 2) \leq 5$$

/* Turn on the channel A main output. */

:OUTPut ON;

/* The following command changes control to channel B. */

:INSTrument:SELect 2;

/* Change channel 2 amplitude to 2 V and the offset to 0.5 V. */

:VOLTage 2;

:VOLTage: OFFSet 0.5;

```
/* Turn on the channel 2 main output. */

    :OUTPut ON;
```

If the above commands are executed correctly, a square waveform will be seen on your oscilloscope at the channel A and B outputs connector.

Controlling the 301/2 Using WaveWiz

To repeat the above sequence of commands using WaveWiz, perform the following sequence of steps having started WaveWiz running.

Open the Instrument Front Panel by clicking on the button

Reset the Model 301/302 to its default condition as listed in Table 3-1. By clicking on the *RST button on the System tab

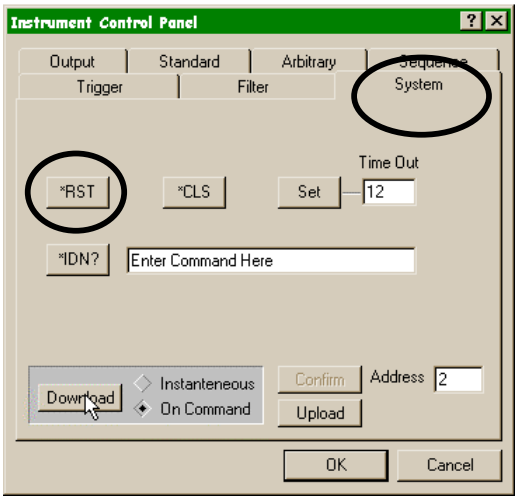

Figure 3.2 Reset button on the System Tab

Select the Standard tab, and on both channel A and B, change the output waveform to square; change the frequency to 20 MHz; change the output voltage to 2.0 V; and the offset to 0.5V by clicking the relevant buttons and entering data into each relevant data entry box (see Figure3.3 below). The command is executed either by clicking OK, which will close the instrument control panel, or by hitting the tab key on the PC keyboard, which will leave the instrument control panel open for further control changes.

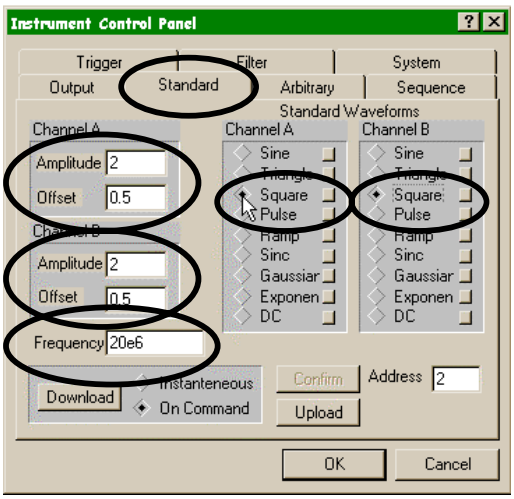

Figure 3-3 Adjusting Standard Waveform types and Parameters

Select the Output tab, and turn on each channel output by selecting Channel on for each channel. Turn on the channel SYNC output, if required.

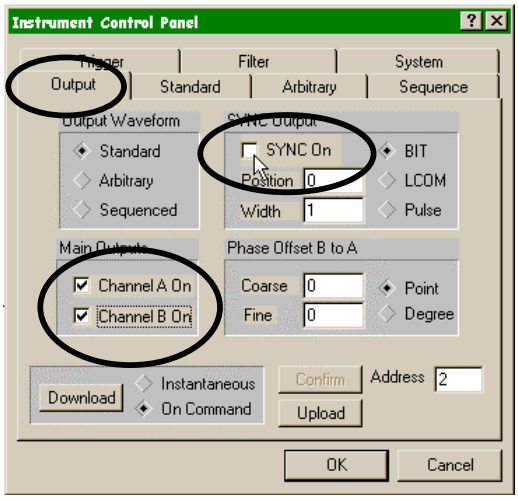

Figure 3-4 Turning on Outputs

If the above commands are executed correctly, a square waveform will be seen on your oscilloscope at the channel A and B outputs connector.

Controlling Instrument Functions

Using the APPLy Command

The APPLy command provides a high level method of programming the generator. Selection can be made for function, frequency, amplitude, offset and other parameters, which are associated with the applied function. For example, the following statement outputs a 2 Vp-p square wave at 1 MHz with a 0 V offset and 10% duty cycle using APPLy:

APPL:SQU 1E6, 2, 0, 10

It is not necessary to enter every parameter with the APPLy command. If only the frequency and offset need to be changed, omit the other parameters while keeping the commas. The other parameters will be set to the power-up default values:

APPL:SQU 10E6,,1

Alternatively, if just the first parameters need to be changed, omit the commas. The other parameters will be set to the power-up default values:

APPL:SQU 4e6,2

Queries can also be made on all parameters associated with a standard function using the APPL: <function_shape>? query. For example, if the generator was programmed using the above APPLy:SQU command, query the square wave parameters using the following query:

APPL:SQU?

The generator returns a string that contains all the parameters associated with the square function similar to the following string:

"1.000000e+6,2.000,0.000,50"

The command:

APPLy:SINusoid {<frequency>,<amplitude>,<offset>,<phase>}

programs the generator to output a sine waveform with frequency, amplitude, offset, start phase and power parameters. Parameters are not optional if the above APPLy command is used. Include all other parameters in the command. The default settings for these parameters are: 1 MHz, 2 Vp-p, 0 V, 0 and 1.

The command:

APPLy:TRIangle {<frequency>,<amplitude>,<offset>,<phase>}

programs the generator to output a triangle waveform with frequency, amplitude, offset, start phase, and power parameters. The default settings for these parameters are: 1 MHz, 2 Vp-p, 0 V, 0 and 1.

The command:

APPLy:SQUare {<frequency>,<amplitude>,<offset>,<duty_cycle>}

programs the generator to output a square waveform with frequency, amplitude, offset and duty cycle parameters. The default settings for these parameters are: 1 MHz, 2 Vp-p, 0 V, and 50%.

The command:

APPLy:PULSe{<frequency>,<amplitude>,<offset>,
<delay>,<high_time>,<rise_time>,<fall_time>}

programs the generator to output a pulse waveform with frequency, amplitude, offset, and delay, rise time, high time and fall time parameters. The default settings for these functions are: 1 MHz, 2 Vp-p, 0 V, 0%, 10%, 10% and 10%. Percentage in this instance refers to percentage of period of the waveform.

The command:

APPLy:RAMP {<frequency>,<amplitude>,<offset>,
<delay>, <rise_time>,<fall_time>}

programs the generator to output a ramp waveform with frequency, amplitude, offset, delay, rise time, and fall time parameters. The default settings for these functions are: 1 MHz, 2 Vp-p, 0 V, 0%, 60% and 30%.

The command:

APPLy:SINC {<frequency>,<amplitude>,<offset>,
<number_cycles>}

programs the generator to output a sine(x)/x waveform with frequency, amplitude, offset, and number of cycles parameters. The default settings for these functions are: 1 MHz, 2 Vp-p, 0 V and 10.

The command:

APPLy:EXPonential <frequency>,<amplitude>,<offset>,

<exponent>}

programs the generator to output an exponential waveform with frequency, amplitude, offset, and exponent parameters. The default settings for these functions are: 1 MHz, 2 Vp-p, 0 V and -10.

The command:

APPLy:GAUSsian {<frequency>,<amplitude>,<offset>,
<exponent>}

programs the generator to output a gaussian waveform with frequency, amplitude, offset, and exponent parameters. The default settings for these functions are: 1 MHz, 2 Vp-p, 0 V and 10.

The command:

APPLy:DC {<percent_amplitude>}

Programs the generator to output a DC level. The DC level is set as a percent of programmed amplitude. The default setting for this function is 100%.

The command:

APPLy:USER
{<segment_number>,<sampling_clock>,<amplitude>,<offset>}

programs the generator to output an arbitrary waveform. The specified segment number must be loaded with an arbitrary waveform before the generator can execute this command successfully. This command lets you specify segment number, sampling clock rate, amplitude and offset. The default settings for these parameters are: 1, 1 MHz, 2 Vp-p and 0 V.

The query:

APPLy:<function_shape>?

queries parameters associated with the specified function shape. Returns a string of values depending on the parameters that are available for the selected function shape.

The query:

APPLy?

queries parameters associated with the currently selected function shape and returns a string of values depending on the parameters available for the selected function shape. For example, if the

generator is programmed to output a sine waveform, the APPL? Command returns: "1e+6, 2, 0 , 0.

Example 2

The following example programs the Model 301/302 using the APPLy command. This example turns on the main output, generates a square waveform, programs frequency to 2 MHz, programs amplitude to 1 V and offset to 1 V. It also changes the square wave duty cycle parameter to 25%.

/* Reset the Model 301/302 to its default condition as listed in Table 3-1. */

```
:RESet;
```

/* Change the output waveform to square, frequency to 2 MHz, amplitude to 1 V, offset to 1 V and duty cycle to 25%. Note that there is no need to use the FUNC:MODE command because the default value after RESet is FIXed. */

```
:APPLy:SQUare 2e6,1,1,25
```

/* Turn the main output on. */

```
:OUTPut ON
```

/*Turn the SYNC output on, if required. */

```
:OUTPut:SYNC ON
```

If the above commands are executed correctly, a square waveform will be seen on your oscilloscope.

Selecting the Active Channel

On power up, the instrument defaults to channel A. That means that each command sent to the generator affects channel A parameters. If you want to send commands to the other channel, you must switch the input to the other channel. Proceeding channel selection, all commands will affect the selected channel only. Use the following command to select the channel you want to program:

```
INSTrument:SELect {1 | 2}
```

When “1” is selected, commands will control parameters that are unique for the channel A output. Selecting “2”, modifies the control to channel B parameter. The default option is “1”. Parameters that are common to both channels may be programmed from either path.

The query:

INSTrument:SELect?

Queries the active channel and returns 1 or 2.

The Control Panel from WaveWiz is shown in Figure 3-5 demonstrates high-level implementation of channel control.

Figure 3.5 Select active channel by clicking on Chan A or B

Enabling the Main Outputs

301/302 waveforms are generated using data points that are downloaded to a waveform memory. Using the sample clock generator, the data is clocked to the digital to analog converter (DAC) which, in turn, generates the waveform shape that was downloaded to the arbitrary waveform memory.

The DAC itself can not be connected directly to the main output because it does not have sufficient drive capabilities, nor does it have the amplitude and offset control, which is required at the output connector. To overcome this problem, a high-power output amplifier circuit is installed directly after the DAC. The amplifier circuit includes gain, offset, attenuation and stand-by control. The output amplifier is the circuit that connects to the output connector.

The Model 301/302 also has low-level, auxiliary output connectors. The low-level outputs are connected directly from the DAC through a buffer amplifier. Amplitude from these connectors is fixed at 1 Vp-p into 50Ω.

The auxiliary outputs are used in applications where signal purity and high signal to noise ratio are crucial. The signal at the output of the DAC circuit predominantly has these signal qualities. To minimize damage that may be caused by external misuse of this output, the signal from the DAC is buffered before it is applied to the low-level output connector. Waveforms from the Main and Auxiliary outputs are available at the same time.

For safety reasons, main output default setting is OFF. Disable or enable the main output using the following command:

OUTPut {OFF | ON}

When the main output state is programmed to ON, the output connector is connected to the output amplifier through a 50Ω resistor and an LED near the output connector illuminates. In the OFF position, the output connector is disconnected from the output amplifier by means of a mechanical relay. Ensure that voltage is **not** applied to the main output connector when the Model 301/302 output state is programmed to ON.

The query:

OUTPut?

queries the state of the main output and returns "0" (OFF) or "1" (ON).

Figure 3.6 Below shows how the Instrument control panel in WaveWiz can be used to enable the main outputs. Checking the relevant box will toggle each output on or off.

Selecting an Output Type

There are three main types of waveforms that the model 301/302 can produce: Standard (fixed), Arbitrary (user) and Sequenced waveforms. Standard waveforms are computed from formulas that are built into the program. The instrument can output arbitrary and sequenced waveforms only after waveform data has been downloaded into its memory.

Use the following command to select the output function type:

FUNCtion:MODE {FIXed | USER | SEQuence}

When “FIXed” is selected, the generator outputs the standard waveform currently selected by the FUNC:SHAP command. When “USER” is selected, the generator outputs the arbitrary waveform currently selected by the TRAC:SEL command. When “SEQuence” is selected, the generator outputs the sequence that is programmed using the SEQ:DEF command. The query:

FUNCtion:MODE?

Queries the output function type and returns FIX, USER or SEQ.

Figure 3.6 Below shows how the Instrument control panel in WaveWiz can be used select the waveform type..

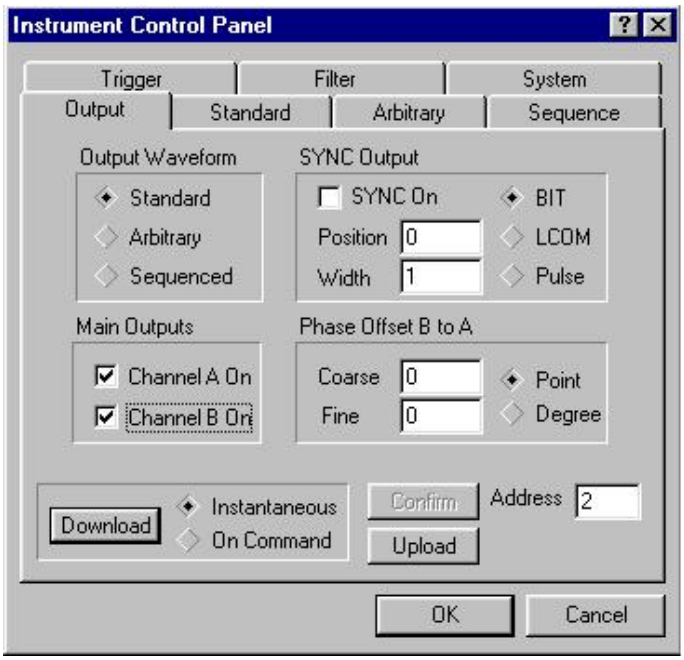

Figure 3.6 Output Control with a WaveWiz Panel.

Selecting a Standard Function Shape

Standard (fixed) waveforms are built into the instrument's program. Nine standard function shapes are available: Sine, Triangle, Square, Pulse, Ramp, Sinc, Exponential decaying pulse, Gaussian pulse, and DC. Every time a standard function is selected the coordinates for this function are re-computed and placed in the waveform memory. Therefore, there is a minimal delay after you select the function until the output starts generating the waveform.

Use the following command to select a standard output function:

FUNCtion:SHAPe {SINusoid | TRIangle | SQUare PULSe | RAMP | SINC | GAUS | EXP | DC}

The selected waveform is generated using the previously selected frequency, amplitude, offset, and other relevant settings. The standard waveform is available at the output connector only after the FUNC:MODE:FIX command is selected.

The query:

FUNCtion:SHAPe?

queries the standard function shape and returns either SIN, TRI or

SQU.,

The number of points used to define each Standard Waveform is the same. Thus, some parameters may not have any effect on the waveform because too few points are available to generate the waveform. The number of points for each standard waveform at various frequencies is given below.

The number of points used for generating standard waveforms at various frequencies is computed as follows:

Frequency $\leq$ 292.9687 KHz, Points = 1024

Frequency > 292.9687 KHz, Points = N where

$$N = 8 \cdot 2 \quad \times \quad INT\left\{\log_2\left[\frac{INT\left(\frac{300}{FREQ}\right)}{8}\right]\right\}$$

Using WaveWiz, the standard Waveforms are selected using the Standard tab in the Instrument Control Panel. Click on the relevant diamond shaped button next to the waveform type required.

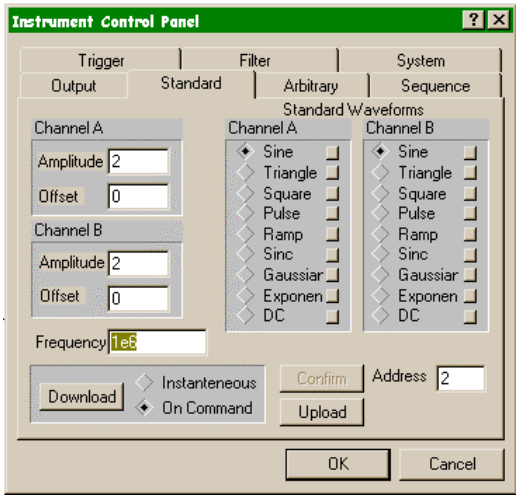

Figure 3.7, Standard Waveform Selection Panel

Each signal type has a number of variable parameters associated with it other than frequency and amplitude. Controls for the parameters are accessed by clicking the box to the right of the standard signal selection. Parameters which may be changed and their units are as follows:

Signal Type	Variable Parameter	Units
Sine	Phase	Degrees
Triangle	Phase	Degrees
Square	Delay	Percentage of Period
	Rise	Percentage of Period
	High	Percentage of Period
	Fall	Percentage of Period
Pulse	Delay	Percentage of Period
	Rise	Percentage of Period
	High	Percentage of Period
	Fall	Percentage of Period
Ramp	Delay	Percentage of Period
	Rise	Percentage of Period
	Fall	Percentage of Period
Sinc	Zero Crossings	Integer Number
Gaussian	Time Constant	Integer Number
Exponential	Time Constant	Integer Number (+ve or –ve)
DC	Amplitude	Percent of Full Scale

Figure3.8 Standard Waveform Adjustable Parameters

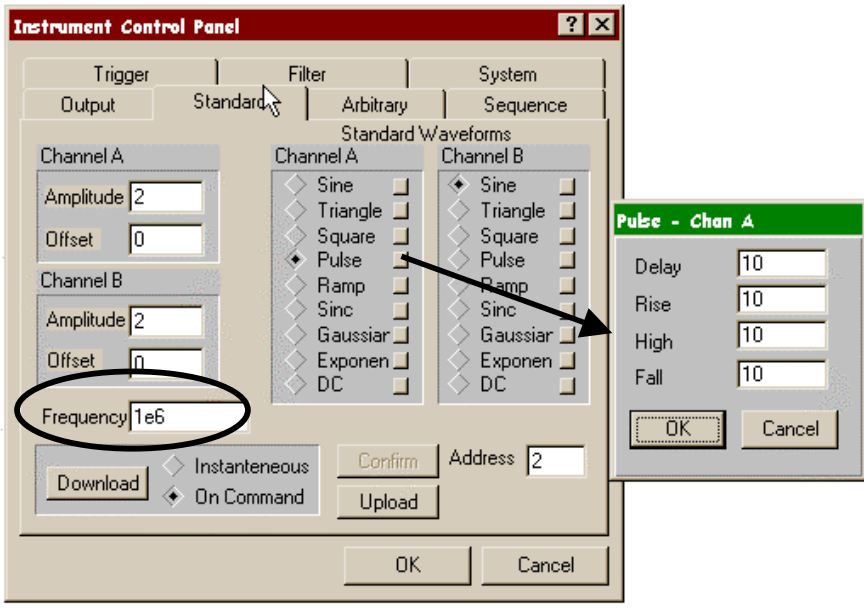

Figure 3.9 Adjusting Parameters of standard signals

Changing the Frequency and Sample Clock

The user should be careful not to confuse waveform frequency with sample clock frequency. The waveform frequency parameter is valid for standard waveforms only and controls waveform frequency at the output connector. On the other hand, the sample clock frequency parameter is valid for arbitrary waveforms only and defines the frequency of which the generator clocks data points.

Standard waveform frequency is measured in units of Hz. Arbitrary waveform sample clock frequency is measured in units of Sa/s (samples per second). The frequency of a given arbitrary waveform at the output connector is dependant on sample clock frequency, the number of data points, and the specifics of the waveform defined

Use the following command to change the frequency for standard waveforms:

FREQuency {<frequency> | MINimum | MAXimum}

MIN selects the lowest frequency allowed for the currently active function. MAX selects the highest frequency allowed for the currently active function. The default frequency setting is 1 MHz for all parameters.

The query:

FREQuency?

queries the frequency setting for the standard function currently active and returns a value in hertz.

The command:

FREQuency:RASTer {<frequency> | MINimum |MAXimum}

Sets the sample clock frequency for the user and sequenced mode parameters. MIN selects the lowest frequency allowed for the currently active segment or sequence. MAX selects the highest frequency allowed for the currently active segment or sequence. The default sample clock frequency setting is 10 MHz for all.

The query:

FREQuency:RASTer?

queries the sample clock frequency setting for the arbitrary segment or sequence currently active and returns a value in Hertz.

Using WaveWiz, frequency of standard signals is also set in the Standard tab in the Instrument Control Panel. See Figure 3.9 above.

Selecting the External SCLK

In cases where synchronization to other instrument in the system is needed, one may use the front panel SCLK input for replacing the internal sample clock generators. Use the following command to select the external SCLK input:

FREQuency:RASTer:SOURce {INTernal | EXTernal}

INT is the default state of the instrument after power up. Select EXT to activate the front panel SCLK input.

The query:

FREQuency:RASTer:SOURce?

queries the sample clock source and returns INT or EXT.

WaveWiz has no specific command control for this function; it is set by sending a SCPI command directly from the system menu in the Instrument Front Panel. (For a more detailed description see later in this chapter).

Programming the Output Amplitude and Offset

Use the following command to program the peak-to-peak amplitude of the generated waveform:

VOLTage {<amplitude>|MINimum|MAXimum}.

MIN selects the smallest possible amplitude. MAX selects the largest possible amplitude. The default amplitude is 2.00 V (into 50Ω).

The query:

VOLTage?

Queries the output amplitude and returns a value in volts.

The command:

VOLTage:OFFSet <offset>

Sets the offset. The default offset is 0 V.

The query:

VOLTage:OFFSet?

Queries the output offset and returns a value in volts.

Using WaveWiz, this is performed in the Standard Tab of the Instrument Control Panel. See Figure 3.10 Below

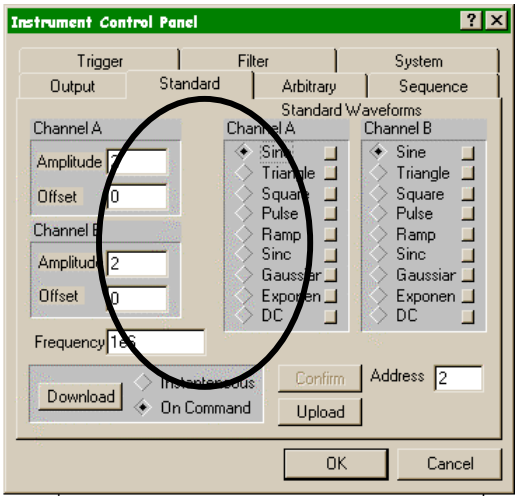

Figure3.10 Adjust standard signal amplitude and frequency

Selecting the Filter Type

Five filters are available for each channel. These filters have fixed cutoff frequencies of which their properties are specified in Appendix A. The built-in filters are switched in after the DAC circuit and are used for reducing the noise, harmonics and spurious signals above the cutoff frequency. More than 1 filter can be applied at any time, the effects being additive.

The built-in filters are available for the user in standard, arbitrary and sequenced modes. The only function where the Model 301/302 does not allow external control is when standard waveforms sinusoidal wave is selected.

Use the following command to activate the filter:

OUTPut:FILTer { OFF | ON}

ON enables the filter. The default filter state setting is OFF.

Use the following command to select the filter type:

OUTPut:FILTer:FREQuency {150M | 10M | 5M | 2.5M | 800K}

Note

The default output function of the generator is the sine waveform. The instrument is using filters to generate this waveform therefore, the state of the OUTP:FILT can not be changed until another output function is selected. A setting conflict error will occur if one attempts to change the filter state before changing to another output function.

The default filter setting is 150M, meaning that following the OUTP:FILT ON command, the 150 MHz filter is the active filter. 10M selects filter having 10 MHz cutoff (3 dB) frequency. Similarly, the 5M, 2.5M and 800K have cutoff frequencies of 5 MHz, 2.5 MHz and 800KHz, respectively.

The query:

OUTPut:FILTer:FREQuency?

Queries the currently selected filter setting and returns either 150M, 10M, 5M, 2.5M or 800K.

The WaveWiz Filter tab from the Instrument Control Panel is shown in

Figure 3.11 below. Each filter may be switched by checking the relevant box. The filters can be applied to the main or auxiliary channel output by clicking the diamond shaped button alongside the relevant selection.

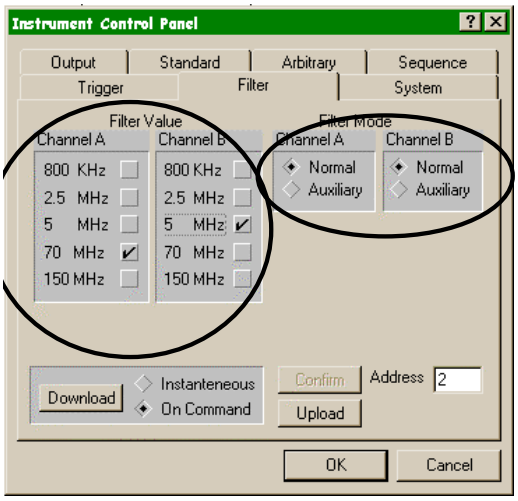

Figure 3.11 Adjusting Filter Parameters

Selecting an Operating Mode

The Model 301/302 offers four operating modes: Continuous, Triggered, Gated and Burst. The selected waveform is repeated continuously when the instrument is set to operate in Continuous mode. In this mode, the Model 301/302 does not require a trigger source to stimulate output cycles. The default operating mode of the instrument is continuous.

Triggered, Gated, and Burst modes require an external signal to initiate output cycles. Information on how to trigger, gate or output a burst of waveforms is given in the following paragraphs. The WaveWiz Trigger control panel (Figure 3.12 below) shows an example of selecting the trigger mode.

Trigger slope and level, speed of the internal trigger generator, count (for bursts) and trigger source are all set on the trigger tab of the control panel. The *TRG button allows a user to manually trigger the generator.

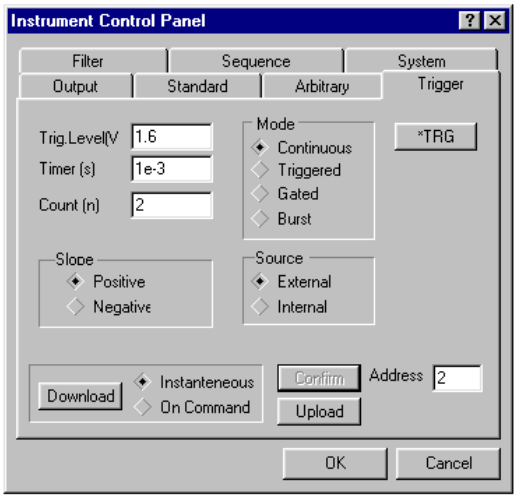

Figure 3.12, Adjusting Trigger Parameters

Triggered Mode

In Triggered mode, the output remains at a certain DC level as long as the TRIG IN signal from the front panel remains inactive. The trigger input is sensitive to either a rising edge or a falling edge. Each time a transition at the trigger input occurs, the Model 301/302 generates one complete output waveform. At the end of the output cycle, the output resumes position at a DC level that is equal to the amplitude of the last point of the waveform.

The Triggered mode operates on standard, arbitrary and sequenced waveforms. Observe the limitations of the trigger signal as listed in the specification section of this manual. To place the Model 301/302 in Triggered mode, use the following command:

INITitiate:CONTinuous {OFF | ON}

OFF places the instrument in Triggered mode. ON restores continuous operation.

The query:

INITitiate:CONTinuous?

queries the instrument operating mode parameter and returns "0" (OFF) or "1" (ON).

In WaveWiz, select trigger mode by clicking the diamond shaped Trigger button under mode on the Trigger tab. (see Figure 3.12 above).

Gated Mode

The Model 301/302 can be set to operate in Gated mode only after the INIT:CONT OFF command has been received. The output remains at a DC level as long as the front-panel TRIG IN signal remains inactive. The gating signal can be programmed to be either active high or active low. As long as the proper level is present at the trigger input connector, the Model 301/302 generates output waveforms. When the gate signal is de-asserted, the output completes the last cycle and resumes position at a DC level equal to the last point of the waveform.

Gated mode operates on standard waveforms, arbitrary waveforms, and on sequences of waveforms. Observe the limitations of the gating signal as listed in the specification section of this manual. To place the Model 301/302 in Gated mode, use the following commands:

```
INIT:CONT OFF
TRIGger:GATE {OFF | ON}
```

The default state for the Gated mode is OFF. Turning Gated mode ON automatically turns Burst mode off.

The query:

```
TRIGger:GATE?
```

queries the gate state and returns "0" (OFF) or "1" (ON).

In WaveWiz, select gated mode by clicking the diamond shaped Gated button under mode on the Trigger tab. (see Figure 3.12 above).

Burst Mode

Burst mode is very similar to Triggered mode with the exception that only one trigger signal is needed to generate a counted number of output waveforms. In Burst mode, the output remains at a DC level as long as the TRIG IN signal from the front panel remains inactive. The trigger input is sensitive to either the rising edge or the falling edge. Each time a transition at the trigger input occurs, the Model 301/302 generates the number of complete output cycles that have been programmed in the burst count parameter. At the end of the burst, the output resumes position at a DC level equal to the last point of the waveform. The burst count is programmable from 1 to 1Meg. The default burst value is 1.

Burst mode operates in standard waveforms and arbitrary waveforms only. Note that the Model 301/302 cannot operate in Sequence and Burst modes simultaneously. Observe the limitations of the trigger signal as listed in the specification section of this manual. To place the Model 301/302 in Burst mode, use the following commands:

```
INITitiate:CONTinuous OFF
```

```
TRIGger:BURSt  ON
TRIGger:COUNt <counts>
```

INIT:CONT OFF places the Model 301/302 in a non-continuous mode. TRIG:BURS ON turns the burst function on. The TRIG:COUN specifies the number of output waveforms after a qualified trigger signal. To ensure proper operation, enable Burst mode after setting up the burst parameters. When Burst mode is enabled, previously programmed trigger or gate modes turn off automatically.

The query:

```
TRIGger:BURSt?
```

queries the state of Burst mode and returns "0" (OFF) or "1" (ON).

The query:

```
TRIGger:COUNt?
```

queries the burst count and returns an integer.

In WaveWiz, select Burst mode by clicking the diamond shaped Burst button under mode on the Trigger tab. (see Figure 3.12 above).

Selecting the Trigger Source

When an external source is not available, one has the option of using the built-in trigger generator to stimulate its output.

Use the following command to select the trigger source for the instrument:

```
TRIGger:SOURce:ADVance {EXTernal | INTernal}
```

EXT is the default trigger source for the Model 301/302. Select INT to use the internal trigger generator. Remember to program the period of the internal generator (as shown later).

The query:

```
TRIGger:SOURce:ADVance?
```

queries the trigger source and returns EXT or INT.

In WaveWiz, select trigger source mode by clicking the relevant diamond shaped button under source on the Trigger tab. (see Figure 3.12 above).

Using the Internal Trigger Generator

The internal trigger generator is a free-running generator, which is asynchronous with the main output generator. When the internal trigger source is selected, the front panel TRIG IN signal is inactive. The internal trigger generator is also usable in Burst mode, but has no effect in Gated mode. To use the internal trigger generator, place the instrument in triggered mode and select the internal trigger generator as the trigger source. Then use the following command to program an internal trigger period:

TRIGger:TIMer <value>

The period of the internal trigger generator can be programmed from 20 μs to 999 ms. The default period is 1 ms. The internal trigger generator is ignored when either an external source is enabled.

The query:

TRIGger:TIMer?

Queries the period of the internal trigger generator and returns a value in seconds.

To perform this in WaveWiz, Enter the value in the data entry box marked Timer (s). (See Figure 3.12 above)

Selecting the Trigger Slope

The trigger slope command toggles edge sensitivity for the trigger input connector. The Model 301/302 can be made sensitive to either positive or negative transitions. Use the following command to select the slope for the trigger signal:

TRIGger:SLOPe {POSitive | NEGative}

Positive going transitions will trigger the Model 301/302 when the POS option is selected. Negative transitions will trigger the Model 301/302 when the NEG option is selected. POS is the default slope. In Gated mode, a high level will gate the generator when the POS option is selected; a low level will when NEG is selected.

The query:

TRIGger:SLOPe?

queries the trigger slope and returns POS or NEG.

In WaveWiz, click on the relevant diamond shaped button in slope on the trigger tab (see figure 3.12 above).

Selecting the Trigger Level

The trigger level command sets the threshold level at the trigger input connector. Trigger level is adjustable from -10 V to +10 V with up to 4 digits of resolution. Trigger level resolution is always 10 mV. Use the following command to set the trigger level for the trigger signal:

TRIGger:LEVel <value>

This sets the trigger level for the signal, which is applied at the TRIG IN connector. The default value is 1.6 V so there is no need to modify this value if you apply a TTL level signal to the trigger input.

The query:

TRIGger:LEVel?

queries the trigger level and returns a value in Volts.

In WaveWiz, enter the required trigger level in Volts in the data entry box marked Trigger Level (v) on the Trigger Tab (see Figure 3.12).

Using the Soft Trigger

The soft trigger command allows you to write a program that can trigger the 301/302 directly from within your application. To use the soft trigger command, place the instrument in TRIG:SOUR EXT mode. Soft triggers are ignored in internal or external modes. Use the following SCPI commands to trigger the instrument:

TRIGger

The IEEE-STD-488.2 common command *TRG has the same effect. Use either command to trigger the Model 301/302 in Trigger, Burst or Triggered Sequence Advance modes.

In WaveWiz a soft trigger is implemented by clicking on the

button on the Trigger tab.

Enabling the SYNC Output

For safety reasons, the SYNC output default setting is OFF. Disable or enable the SYNC output using the following command:

OUTPut:SYNC {OFF | ON}

When the SYNC output state is programmed to ON, the SYNC output connector generates signals, which are triggered by signals selected using the SYNC:SOUR command. In the OFF position, the SYNC connector has no output. It is connected electrically to internal circuitry at all times therefore, be careful not to apply voltage to the SYNC

output connector. The default SYNC position is the point 0 (the first point of the output waveform). The position of the SYNC signal can be programmed using the OUTPUT:SYNC:POS:POIN command.

The query:

OUTPut:SYNC?

queries the state of the SYNC OUTPUT and returns "0" (OFF) or "1" (ON).

Using WaveWiz, the SYNC output is turned on and off from the output tab of the control panel. Check SYNC On to toggle the sync on and off. See Figure 3.13 below.

Assigning the Source For The SYNC Output

The SYNC output generates a synchronized signal at the beginning of the waveform or at any position on the waveform as may be programmed by the OUTP:SYNC:POS command. The validation source for this command is selectable from a number of options. Use the following command to select the source for validating the SYNC output:

OUTPut:SYNC:SOURce {BIT | LCOMplete}

BIT Generates a sync signal from the SYNC Output BNC every time the segment is output in User mode and in Sequenced mode. The position of the sync output relative to the waveform can be programmed using the OUTPUT:SYNC:POS command. The BIT signal is recommended for use in continuous mode.

LCOMplete Generates a sync signal in SEQ mode only once when the selected segment appears for the first time in the sequence. The identity of the segment can be programmed using the TRAC:SEL command. The sync position along the selected waveform can be programmed using the OUTPUT:SYNC:POS command. The LCOM signal is recommended for use in Sequenced mode.

The query:

OUTPut:SYNC:SOURce?

queries the signal source for the SYNC output and returns BIT, or LCOM.

These modes are selected in WaveWiz by checking the relevant box in the sync output section (see Figure 3.13 below)

Selecting the SYNC Position

The SYNC output can be programmed to output the SYNC signal at any time referenced to the output waveform (expressed in waveform points). This function is available in USER and SEQ modes only. Use the following command to select the SYNC output position:

OUTPut:SYNC:POSition <value>

The SYNC position can be selected from point 0 to the last point of the active waveform. SYNC position has to be programmed for each segment. The default SYNC position is at the beginning of the segment or waveform.

The query:

OUTPut:SYNC:POSition?

queries the output SYNC position and returns an integer value.

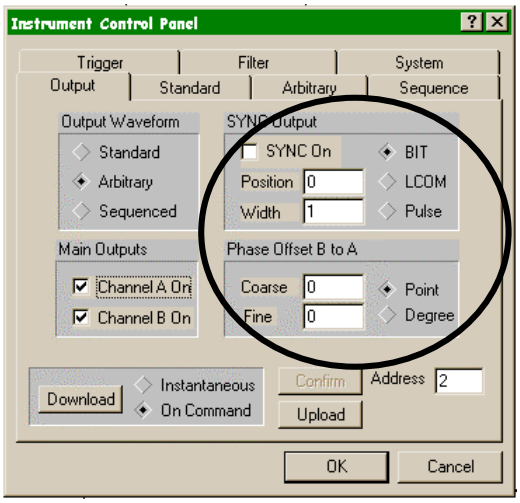

Figure 3.13 Controls for the SYNC output are on the Output tab

Generating Arbitrary Waveforms

The Model 301/302 cannot generate arbitrary waveforms without first loading them into memory. A description of the arbitrary waveform function and an explanation of how to load waveforms into memory are given in the following paragraphs.

What Are Arbitrary Waveforms?

Arbitrary waveforms are generated from digital data points, which are stored in memory. Each data point has a vertical resolution of 12 bits (4096 points), i.e., each sample is placed on the vertical axis with a precision of 1/4096.

The Model 301/302 has the following waveform memory capacity:

4 Meg – standard memory configuration
16 Meg optional memory expansion

Each horizontal point has a unique address - the first being 00000 and the last depends on the memory option. In cases where smaller waveform lengths are required, the waveform memory can be divided into smaller segments. Then it is possible to select which segment is sampled, how many times and in what sequence.

When the instrument is programmed to output arbitrary waveforms, the clock samples the data points (one at a time) from address 0 to the last address. The rate at which each sample is replayed is defined by the sample clock rate parameter. The Model 301/302 provides programmable sample clock rates from 100 mSa/s to 300 MSa/s.

The Arbitrary Waveform Control Panel (figure 3-14) in WaveWiz allows adjustment of arbitrary waveforms.

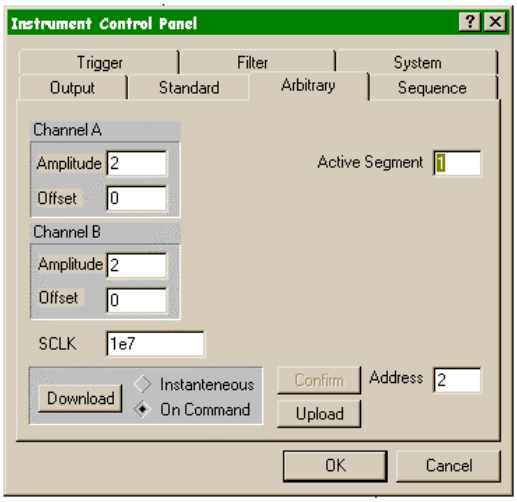

Figure 3.14 WaveWiz Arbitrary Waveform Control Panel

Unlike the built-in standard waveforms, arbitrary waveforms must first be loaded into the instrument's memory. Correct memory management is required for best utilization of the arbitrary memory. An explanation of how to manage the arbitrary waveform memory is

given in the following paragraphs.

Arbitrary Memory Management

The arbitrary memory in comprised of a finite length of words. The maximum size arbitrary waveform that can be loaded into memory depends on the option that is installed in your instrument. The various options are listed in Chapter 1 of this manual. If you purchased the Model 301/302 with in its basic configuration, you should expect to have 4 Meg to save waveforms.

Waveforms are created using small sections of the arbitrary memory. The memory can be partitioned into smaller segments (up to 4096) and different waveforms can be loaded into each segment, each having a unique length. Minimum segment size is 16 points, as long as its playback time is more than 10 μs. Information on how to partition the memory is given in the following paragraphs.

Memory Management Commands

Arbitrary memory can be divided into smaller segments; up to 4096 different arbitrary waveforms can be stored in the Model 301/302's memory. The length of each segment and its associated sample clock rate are left to the user's discretion. To partition the arbitrary waveform memory, use the following command:

TRACe:DEFine <segment_number>,<length>

Note that numbers, not names, are assigned to segments. Segment numbers can range from 1 through 4096. The order of assignment is not important as long as segment size does not change after they have already been defined.

Note

Minimum segment length is 16 points. Segment size may be set from 16 points to the maximum memory size, in increments of 8 points. A size of 1002 is not a valid segment length since it is not evenly divisible by 8. An error will occur if 1002 points is assigned to a segment.

You cannot query the TRAC:DEF command so you must keep good track if you intend to partition the memory into many segments. If a mistake is made and removal of one or more segments from the active directory is needed, use the following:

TRACe:DELete <n>

where <n> is the segment number to be removed from memory. Note that if a segment is deleted, the memory portion that belonged to this segment is no longer accessible. The next segment that is defined will be placed after the last defined memory segment. However, if the last

segment is deleted, the next downloaded segment will be written on top of the deleted one. There is danger that by using the TRAC:DEL command often large portions of memory will remain unused. It is, therefore, suggested that you periodically clear the entire memory and only reload waveforms that you intend to use.

To partition the memory from the beginning, use the following command:

TRACe:DELete: ALL

In WaveWiz use the button.

CAUTION

This command will destroy waveforms that were previously loaded into memory. After using this command, waveform segments will line-up from address 0 upwards.

Loading Arbitrary Waveforms

There are three ways to load waveforms into the 301/302 these are using 1) WaveWiz, 2) LabVIEW driver, or 3) Low-level programming. When using WaveWiz, disregard most of this chapter and move on to "Using WaveWiz to Generate Arbitrary Waveforms" as this software does the work for you. If you write your own application or instrument driver, use the following commands to load data into a specific memory segment.

First, define the work area. Define the segment number and its associated length. The segment length must be divisible by eight or an error will occur. For example, to use segment number 8 with a waveform length of 1048 points use this command:

TRACe:DEFine 8,1048

Next, make segment 8 the active segment. The active segment must be selected because as waveforms are loaded, the Model 301/302 must be notified as to where to place the data it receives. Select the active segment using the following command:

TRACe:SELect 8

The next step is to transfer data to the active segment. Data is loaded into the Model 301/302 using high-speed binary transfer. A special command is defined by IEEE-STD-488.2 for this purpose. High-speed binary transfer allows any 8-bit bytes (including extended ASCII code) to be transmitted in a message. This command is particularly useful for sending large quantities of data. The Model 301/302 uses this command to receive waveforms from the controller:

TRACe #42096<binary_block>

This command causes the transfer of 2096 bytes of data (1048) points into the active memory segment. The ASCII "#" ($23) is the start of the binary data block. "4" designates the number of digits that follow. "2096" is the even number of bytes to follow. The generator represents binary data as 12-bit integers, which are sent as two bytes. Therefore, the total number of bytes is always twice the number of data points in the waveform. For example, 2096 bytes are required to download a waveform with 1048 points. Bytes are sent in byte-low, byte-high order. The FORM:SWAP command can be used to reverse this order.

When sending binary blocks to the Model 301/302, the final byte must be transmitted with the EOI bit set. Carriage Return and Line Feed will not be detected as terminators. This permits the values ODH and OAH to be used as data points. The IEEE-STD-488.2 definition of Definite Length Arbitrary Block Data Format is demonstrated in Figure 3-15.

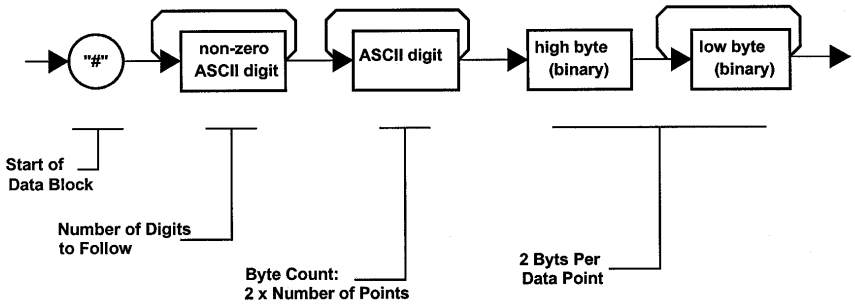

Figure 3. 15, Definite Length Arbitrary Block Data Format

16 bits of data are sent to the Model 301/302 even though only 12 bits are required to generate the waveform. The order of bytes and bits and their values are shown in Figure 3-16.

NOTE

Figures 3-15 and 3-16 show IEEE-488.2 standard definition of Arbitrary Block data Format. The actual order of bytes sent to the 302 is reversed. Byte will be sent to the 302 in

byte-low byte-high order.

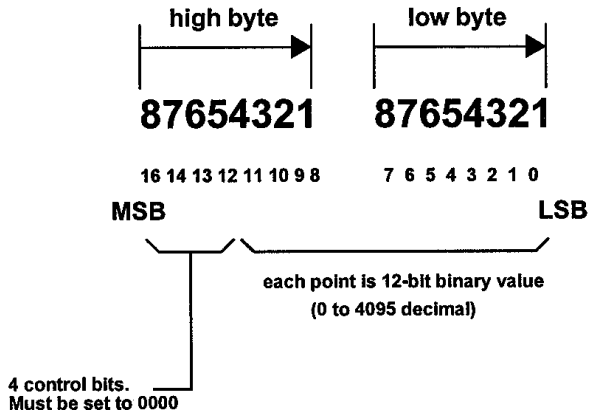

Figure 3.16, 12-Bit Waveform Data Format

Note

The Model 301/302 operates in interlaced mode where eight memory cells generate one byte of data. Segment size can be programmed in numbers evenly divisible by eight only. For example, 2096 bytes is an acceptable length for a binary block. 2002 is not a multiple of 8, therefore the generator will generate an error message if this segment length is used.

Reversing Byte Order

Binary data is sent to the Model 301/302 in byte-low byte-high order. This order can be reversed using the following command:

FORMat:BORDer {NORMal | SWAPped}

The default is NORM. This command is useful only for binary block transfers. The query:

FORMat:BORDer?

queries the byte order configuration and returns "NORM" or "SWAP".

Using the DMA

DMA data transfer is the fastest way to get waveforms to the Model 301/302. In DMA mode, the internal CPU disconnects from the waveform memory and passes access to the GPIB. The internal data bus is connected directly to the GPIB data bus, and data is downloaded into the memory in binary blocks. Bytes and bit order are the same as for the Arbitrary Block transfers as shown in Figures 3.15 and 3.16 except, low-byte is sent first and high-byte second. After the data is loaded into the Model 301/302, control is returned to the instrument.

The instrument has to be told when to receive data, send data, surrender or gain control. DMA commands are explained below.

To write to a segment, you must first define it using the TRACe:DEFine command. The trace must then be selected using the TRACe:SELect command. Refer to Loading Arbitrary Waveforms for more information.

The command:

DMA {(OFF) | ON] (OFF is automatic with the last word)

places the Model 301/302 in DMA state when ON is selected. After this, the instrument cannot accept normal commands. Data must be sent to the generator from the host computer. Normal command mode is resumed when the DMA state is terminated. The DMA state is terminated automatically to DMA OFF when the most significant bit of the high byte is set to “1”. Therefore, your last waveform point must contain DMA termination code as explained above.

The following sequence should be used for DMA data transfers.

1. Controller sends commands:

   TRAC:DEF (n),(m)
   TRAC:SEL <n>
   DMA ON

3. Use an I/O routine such as ViMoveAsync (from the VISA I/O library) to transfer binary blocks of data to the generator.

4. Last waveform point is sent with high byte’s MSB bit set to “1”

5. DMA transfer is completed and CPU resumes control.

Using WaveWiz to Generate

WaveWiz has the ability to produce arbitrary waveforms in 5 ways.

Arbitrary Waveforms

1. By combining pieces of standard waveforms
2. By using waveform drawing techniques on the PC screen
3. By using the mathematical equation editor
4. By using previously saved waveforms
5. By using data from other applications

A finished waveform may comprise elements from all of these methods.

To start producing a waveform, the initial step is to set up initial conditions using the axis selection in the setup pull-down menu. This allows the user to set amplitude of the resultant signal and to set horizontal attributes such as record length and sample clock speed. (see Figure 3.17 below

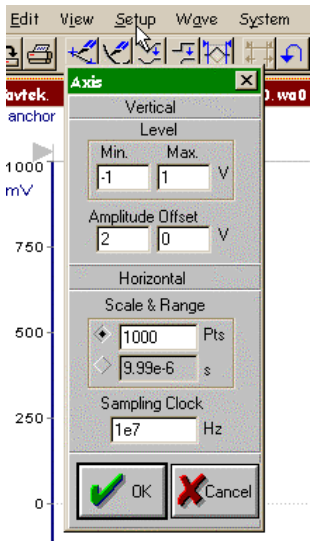

Figure 3.17 Initial step is to set up Vertical and Horizontal conditions

Using standard Waveforms to Generate Arbitrary Waveforms

The main menu has a pull down called “Wave” This menu has similar selections to the standard waveform selections on the instrument control panel, but now the user has control over more signal attributes, including where the signal starts and stops within the record. By combining different standard waveforms with the arbitrary waveform record, the user can define custom or arbitrary waveforms See Figure 3.18 below.

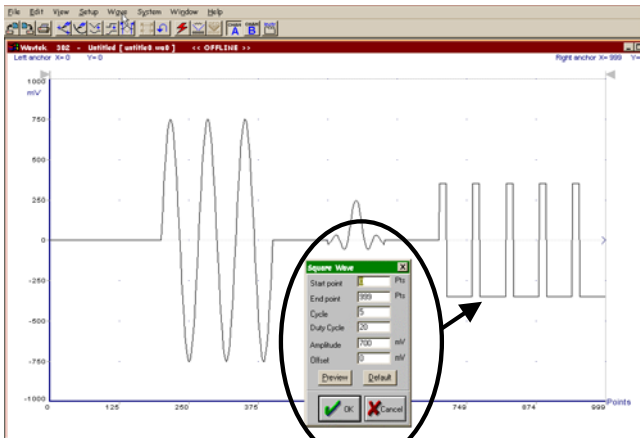

Figure 3.18 Arbitrary waveform made by combining some standard waveforms. The pop-up menu for each wave allows definition of all waveform attributes

Using Waveform drawing and editing tools to generate arbitrary waveforms

The WaveWiz Toolbar has 5 waveform drawing and editing tools. These are

Point to point draw (Autoline). Select any point on the waveform axis by moving the mouse pointer to that point then left click to select it. Move the cursor to the next point and left click, and a straight line will be drawn between the two points. This process of selecting points and drawing lines between them is continued until the mode is exited by right clicking the mouse.

Hand draw waveforms (Sketch). This mode allows the user to create waveforms by using the mouse pointer as a pencil over the waveform axis. Position the cursor to the beginning of the hand drawn part of the waveform and click and hold down the left button. By dragging the mouse new waveform points will be added following the exact path of the mouse

Smooth. This function will smooth out selected parts of waveforms. Selection is made by dragging the Handles

to the piece of waveform to be smoothed. The section of waveform which will be processed will appear on a white background, the rest of the waveform (not to be processed) will appear on gray.

Filter applies low pass filtering to the selected part of the waveform (selection made as above). When selecting this function a pop-up box allows the user to control the roll-off of the filter by entering a number. The higher the number, the greater the filtering effect.

Invert inverts the selected part of the signal. Note: this also inverts the DC component of the signal as well as the AC component.

Using Equation Editor to Generate Arbitrary Waveforms

WaveWiz incorporates an equation editor to enable the user to build waveforms which can be defined by mathematical functions. It can be found in the “Wave” Pull down menu. The waveform expression is entered into the equation field using standard mathematical notation. Available operations, functions, constants, variables and file types can be found by clicking on the

button. Mathematical waveforms can be defined in either the whole or a part of the waveform records and combined with waveforms built using the other methods. Examples below show how this maybe used to generate waveforms of varying complexity.

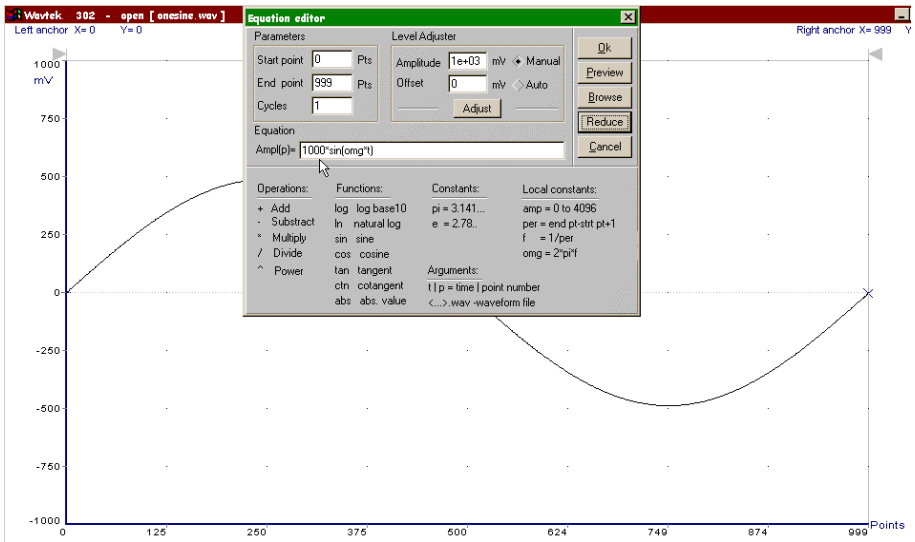

Figure 3.19a Using equation editor to generate one cycle of sine wave

In the above example (figure 3.19a) WaveWiz will produce one cycle of sine wave with a peak to peak amplitude of 1000mV (1V). The 1000mV is specified at the beginning of the equation i.e 1000*sin(omg*t)

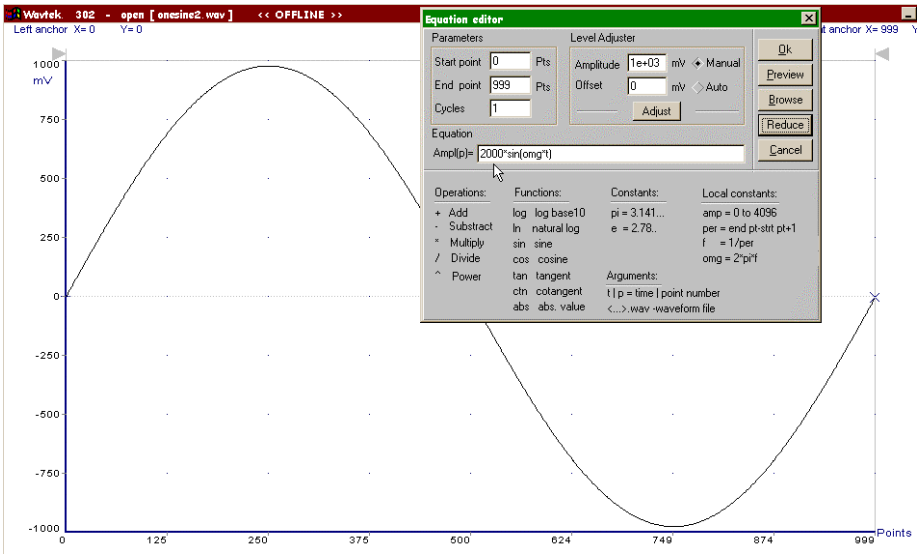

Figure 3.19b Using equation editor to generate one cycle of sine wave with a higher amplitude

In the above example (Figure 3.19b) WaveWiz will produce one cycle of sine wave with a peak to peak amplitude of 2000mV (1V). The 2000mV is specified at the beginning of the equation i.e **2000***sin(omg*t)

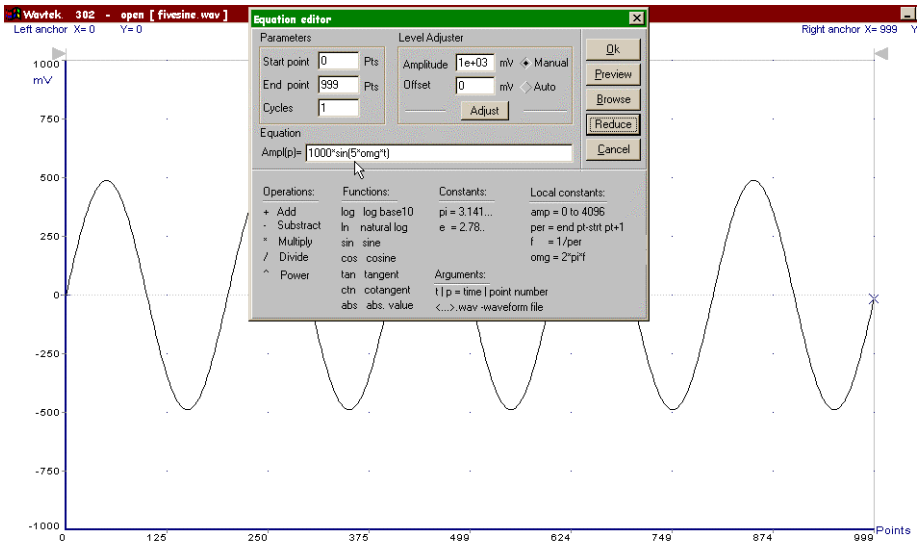

Figure 3.19c Using equation editor to generate five cycles of sine wave

In the above example (Figure 3.19c) WaveWiz will produce five cycles of sine wave with a peak to peak amplitude of 1000mV. Five cycles are specified by the figure 5 within the brackets in the equation i.e. 1000*sin(**5***omg*t).

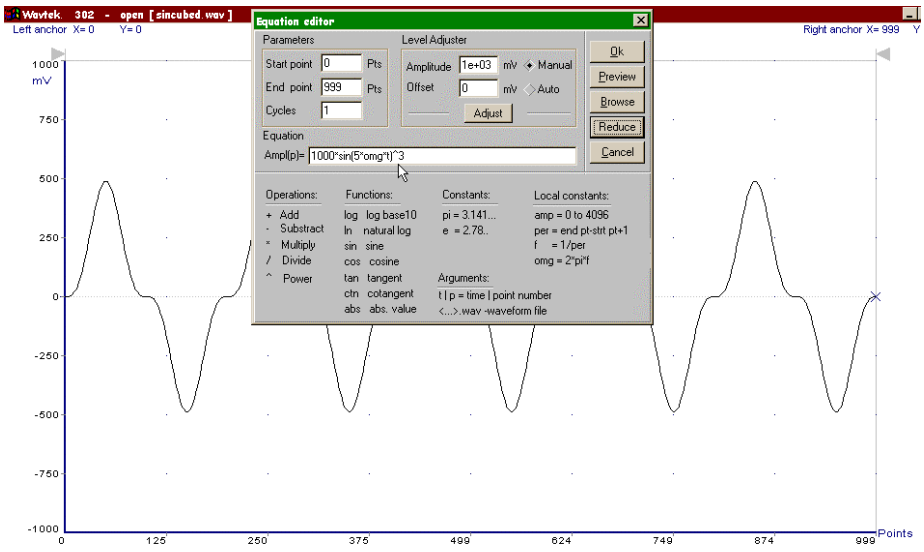

Figure 3.19d Using equation editor to generate five cycles of sine cubed wave

In the above example (Figure3.19d) WaveWiz will produce five cycles of sine wave with a peak to peak amplitude of 1000mV. Sine cubed is specified at the end of equation i.e. 1000*****sin(5*omg*t)**^3**.

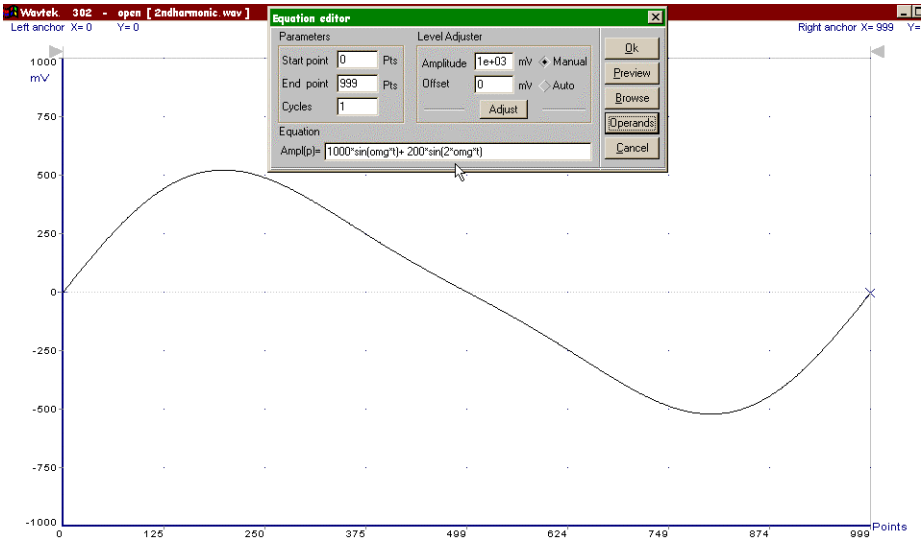

Figure 3.19e Using equation editor to add second harmonic distortion to sine wave

In the above example (Figure 3.19e) 20% second harmonic distortion has been added to the original sinewave from Figure 19a. The original waveform had a peak to peak value of 1000mV so 20% second harmonic is equivalent to 200 mV . The frequency of the second harmonic is obviously double that of the fundamental, so term +**200***sin(**2***omg*t) is added to the original equation.

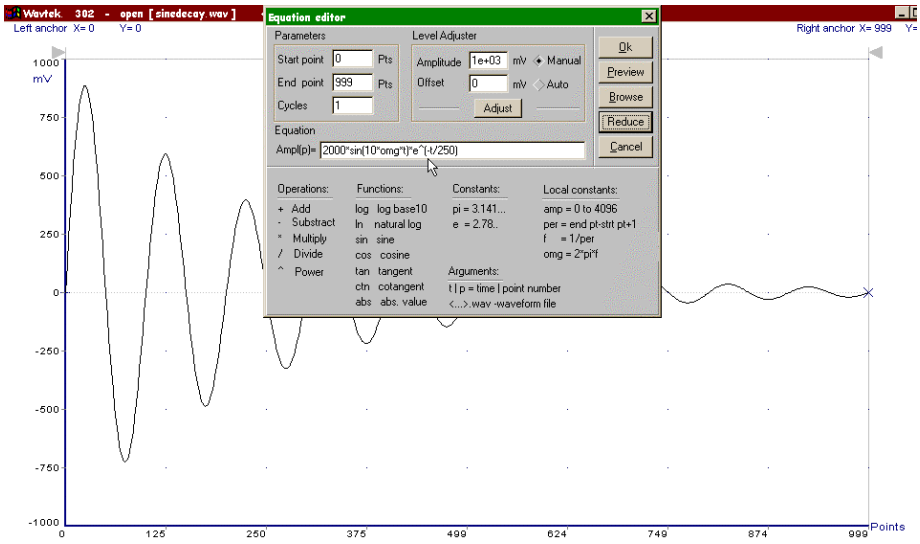

Figure 3.19f Using equation editor to generate exponentially decaying sine Wave

In the above example (Figure 19f) 10 cycles of sinewave are made to decay exponentially. The original expression for a standard sinewave is multiplied term e^(-t/250). Increasing the value of the divisor (200 in this case) will slow down the rate of decay

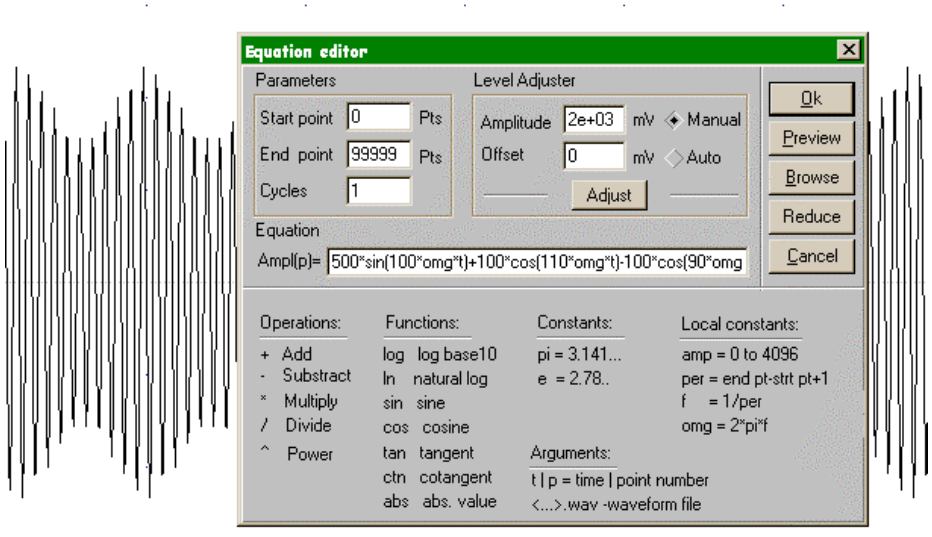

Figure 3.19g Using equation editor to build amplitude modulated signal with upper and lower sidebands

The last example (Figure 19g) above is the most complex to be discussed here. Here, 100 cycles of sinewave are amplitude modulated with 10 cycles of sine wave with a modulation depth of 20%. To achieve this, the upper and lower sidebands are defined separately and added to the fundamental or carrier. The upper sideband is produced by the expression 100*cos(110*omg*t) and the lower sideband by the term 100*cos(90*omg*t).

Using Previously Saved Waveforms to Generate Arbitrary Waveforms

Waveforms saved previously can be re-used and resent to the 301/302. To save or open a waveform, use the “waveform” selection from the file menu, and select “save as” or “open” as appropriate. See Figure 3.20 below.

Using the “save” or “open” options from the file menu saves or opens complete instrument set-ups rather than just waveform data.

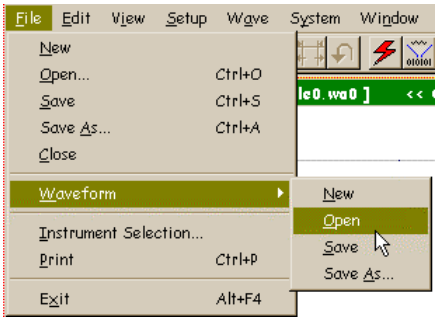

Figure 3.20 opening or saving waveforms

Using Files From Other Applications to Generate Waveforms

Any application which can generate data that can be saved as a .csv or .asc file can be used to build waveform data. For example, data from Microsoft Excel speadsheets or Matlab simulations can all be used as sources of waveform data. To import data use waveform open as above, then select the relevant file extension of the file to be imported on the file type dropdown menu (see Figure 3.21 below).

Data used must have a record length which is a multiple of 8.

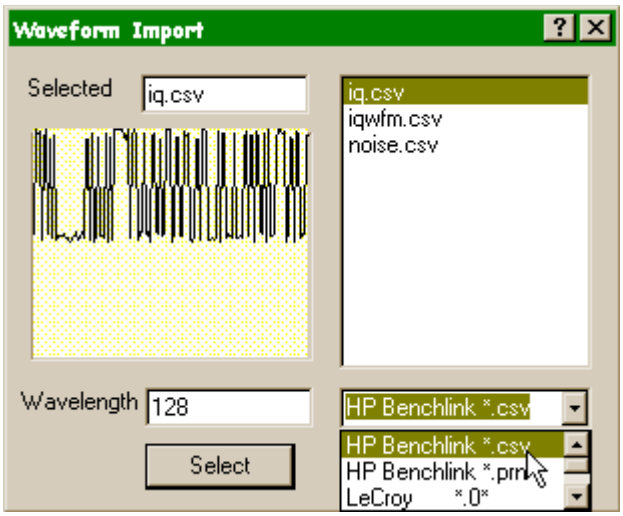

Figure 3.21 Importing data from other applications using .csv file format

Sequenced Waveforms

What Are Sequenced Waveforms?

Sequenced waveforms are made of a number of arbitrary waveforms, which can be linked and repeated in user-programmable order. Sequenced waveforms are generated from waveforms stored in a library of memory segments (sequence table). Before using a sequence of waveforms, load arbitrary memory with the required waveforms. Use TRAC# or DMA methods to load waveforms into memory. Information on how to partition the memory and load waveforms is given in the section entitled **Generating Arbitrary Waveforms**.

An example of how sequenced waveforms work is demonstrated in figure 1.1a through 1.1d. The sequence generator lets you link and loop segments in user-defined order. Figure 1.1d shows a sequence of waveforms that were stored in three different memory segments.

To eliminate the need of downloading a new sequence table every time you change your test setup, the 301/302 can store 16 different sequences for you, each having a unique number of links and loops. You can then use these sequences one at a time, or link them all to one large sequence. Sequenced sequences are explained later.

Sequence Commands

The following is an overview of how to define and program a sequence of arbitrary waveforms.

A sequence is made of steps or links between segments. A step can stand on its own or link to another step. It is possible to have only one step in a sequence but the output will look like a continuous waveform. If only one step is specified and the Model 301/302 is placed in Triggered mode, the output will behave as in Burst mode, where the repeat number replaces the burst count parameter.

You may download 16 different sequences to locations numbered from 1 through 16. However, if you plan on using more than one sequence you must first specify the maximum number of sequences you intend to use and only then download sequence tables.

The number of sequences and the number of links in sequences are inversely proportional. The more sequences you want to use, the less number of links you can specify for each sequence. The following list

shows the relationship between links and sequences.

Sequences	Links
1	4096
2	2048
4	1024
8	512
16	256

For example, if you plan to use 5 sequences, your choice must be 8 sequences and the maximum number of links that you'll be able to specify for each sequence is 512.

Use the following command to specify the number of sequences you intend to use:

MSEQuence:SIZE <size>

Size specifies the number of sequences. Numbers range from 1 through 16. The default value is 1, therefore if you do not plan to use more than one sequence in your test setup, there is no need to use this command at all.

The next step is to start defining the active sequence. If you have only one sequence, you can go ahead and start downloading its sequence table. If you planned to use more than one sequence, you first have to tell the instrument, which of the sequences is active for downloading its table.

To select the active sequence for table download use the following command:

SSEQuence:SELect <sequence_number>

After you use this command, sequence definitions will apply to the sequence number you selected with the above command.

You can now start downloading sequencer steps. Each step has two parameters: segment number and repeat counter. The segment number specifies which segment will be linked, and the repeat counter specifies how many times the segment will loop.

There are two ways to download a sequence table to the 301/302: 1) Using standard ASCI commands and 2) Using binary fast download command. If your application requires downloading just a few steps, you can use the standard ASCII table downloads, as shown below. In cases where large tables have to "dumped" to the generator and where timing is critical for the system, you can use the Fast Binary

Download method. The later is a bit more complex because it requires writing external applications however, once understood, it could download long tables in a split of a second. The fast binary download format is explained later in this chapter.

For downloading standard ASCII sequence tables, use the following command:

SSEQuence:DEFine
{<step_number>,<segment_number>,<repeat>[,<0/1>]}

Use this command up to 4096 times, each time for a different step and for a different segment number and repeat combination. Note that the same segment number can be used for different sequence steps. The SSEQ:DEF command does not change the FUNC:MODE setting. Unless the FUNC:MODE SEQ command is used, the SSEQ:DEF command has no immediate effect on the output waveform or function.

TIP

Every time that the SSEQ:DEF command is sent to the generator, it attempts to rebuild the sequence table and re-generate the sequence at the output. This process takes a long time and slows the download process. Therefore, it is recommended that you use the SSEQ:DEF command in either Fixed or User modes but not while you are in sequenced mode.

The sequence generator goes through its steps in descending order. In continuous mode, the sequence is repeated automatically after completing the last step. In Triggered mode, the output stops at the last point of the last waveform in the sequence. In Gated mode, the sequence is always completed after the gate stop signal.

In case you want to remove a step from the sequence table, use the following command:

SSEQuence:DELete <n>

Where <n> is the step number to be removed from the sequence. To wipe out the sequence table use the following command:

SSEQuence:DELete:ALL

CAUTION

SSEQ:DEL:ALL is destructive. Use this command with caution because it will completely and irreversibly erase the sequence table

because it will completely and irreversibly erase the sequence table from the memory.

Fast Binary Sequence Table Download

As was discussed previously, there are two ways you can download a sequence table: 1) ASCII download and 2) Fast binary download.

The traditional ASCII method of downloading a sequence table is inefficient in cases where the table is large and where short download time is critical to the speed of the system. There are provisions built into the Model 301/302 for fast binary downloads of sequence tables.

The sequence table contains sequence steps, segment number and how many times the step is repeated.

The following procedure assumes that you have already downloaded data and partitioned your memory into segments.

1. Prepare the sequence table using the format shown in Figure 3-9.

2. Use the commands below to download the sequence table to the generator:

   SSEQ:DATA#<header><binary_block>

Actually, you are downloading a Definite Length Arbitrary Block Data exactly as shown in Figure 3-6 and explained above in the section about downloading arbitrary waveforms.

The format of the binary block is shown below.

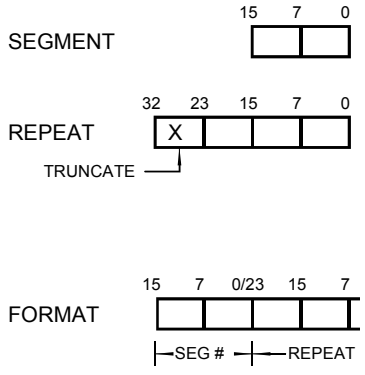

Figure 3.22, Sequence Table Download Format

There are a few things to consider when you prepare sequence tables for the fast download format:

1. Data for each step is fixed and is comprised of 5 bytes

2. The number of bytes in a complete sequence table must divide by 6. The Model 301/302 has no control over data sent to its sequence table buffer during binary block downloads. Therefore, wrong data and/or incorrect number of bytes will cause erroneous sequence setting.

Using WaveWiz to Generate Sequences

Downloading Segments

Segments are built and downloaded in turn to the 301/302 using WaveWiz. Valid Waveforms can be waveforms using any of the previously discussed methods. Prior to downloading the waveform, it is necessary to set the segment number to where the waveform will be sent. This is done using the segment control window which is turned on by selecting “view segment window” in the view pull down menu.

Select the segment number by entering that number in the box, then clicking on the Sel button.

Once the required waveform is defined, download it to the selected segment by clicking on the button on the toolbar. Repeat this process for every segment required.

Selecting Number of Sequences

In WaveWiz, use the sequence button on the sequence tab in the Instrument Control Panel. The sequence table pop-up menu appears.

of Sequences

The active sequence is set by entering the number in the Active Sequence box.

For a discussion on implications of numbers of sequences, see earlier section describing commands for sequences.

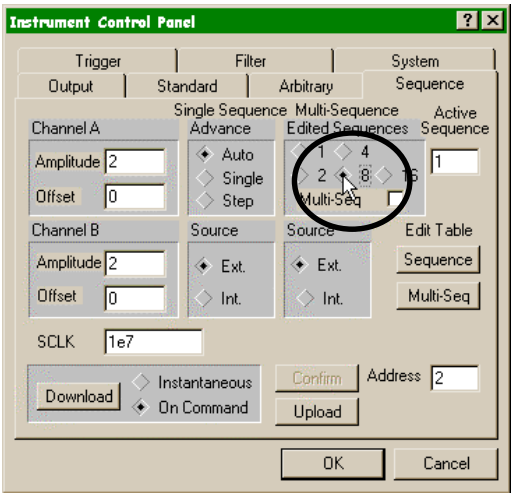

Figure 3.23 Selecting number of sequences to be used

Selecting active Sequence

Use the sequence button on the sequence tab in the Instrument Control Panel. The sequence table pop-up menu appears. The active sequence is set by entering the number in the Active Sequence box.

To Enter Sequences, use the data entry box marked within the sequence table. “Link” is the numeric position of that particular step in the sequence; Loop is the number of times that link will repeat before moving on to the next link in the sequence. Segment is the number of the waveform segment that should be outputted while that link is executing. As an example the following sequence

Link#	Loop(s)	Segment #
1	1	1
2	8	4
3	2	2

Will result in an output consisting of segment 1 repeated once, then segment 4 repeated 8 times followed by segment 2 twice.

To add or delete links, click on the append or delete buttons.

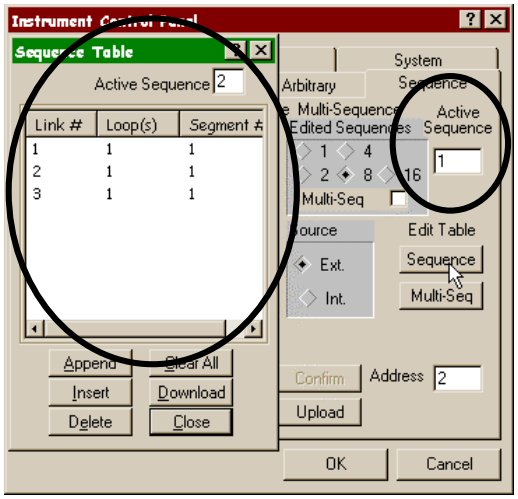

Figure 3.24 Selecting the active sequence and entering sequences

Running Sequences Using WaveWiz

If “output waveform” is set to “Arbitrary” on the output tab of the Instrument control panel, selecting different segments in the segment control window will result in that segment being output from the 301/302 (if the output is turned on). To run a sequence, select “sequenced” on the output tab. The sequence defined in the sequence table will now be output.

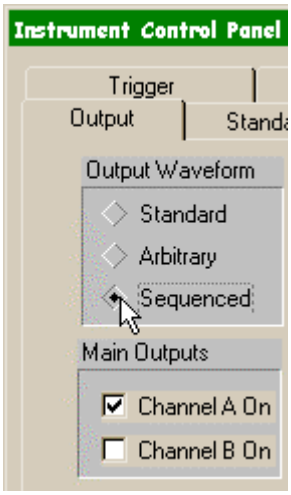

Figure 3. 25 Selecting Sequence output mode

Sequences may be advanced in a number of different ways dependent on application. These are also selected on the sequence tab. For a discussion on the various advance modes, see section Sequence Advance Commands.

Generating Sequenced Sequences

What Are Sequenced Sequences?

The model 301/302 can store 16 different sequence tables. Then, you can program the instrument to generate either one of these sequences at various stages of your test routines. There are cases however, that require “nested” testing or said differently, you need to sequence waveforms that are actually made of a sequence.

The model 301/302 is capable of linking sequences to generate a macro linker of sequences, called – sequenced sequences.

There are a few rules to observe while generating such macro:

1. Before building a sequenced sequence table, you must first specify the number of sequences you intend to program using the command MSEQ:SIZE, then download individual sequence tables to the Model 301/302.

2. You can loop Individual links or steps within a standard sequence. You can link sequences in any order as long as they were pre-defined however, sequences can not loop (repeat) in a sequenced sequence table. The maximum number of links in a sequenced sequence is 16.

3. Fast binary download format is not available for sequenced sequences table.

The procedure for defining a table is to first specify how many sequences participate in this macro sequence then, to download sequence tables. Use the following command to specify the number of sequences:

MSEQ:SIZE <size>

Size specifies the number of linked sequences in the current table. Numbers range from 1 through 16.

The next step is to select the active sequence and to download its associated table. Information on how to download sequence tables is given in the Sequence Commands section of this manual.

When you finally have all sequences downloaded to the generator, use the following command to define the macro sequence:

MSEQuence:DEFine <step_number>, <sequence_number>

Both <step_number> and <sequence_number> are integers. Step number may range from 1 through 16. Use ascending order when you first program this table. Sequence numbers may range from 1 through 16 and can be used randomly within a table.

TIP

Every time that the MSEQ:DEF command is sent to the generator, it attempts to rebuild the sequence table and re-generate the sequence at the output. This process is taking a long time and slows the download process. Therefore, it is recommended that you use the MSEQ:DEF command in either Fixed or User modes but not while you are in sequenced mode.

The sequence generator goes through its steps in descending order. In continuous mode, the sequence is repeated automatically after completing the last step. In Triggered mode, the output stops at the last point of the last waveform in the sequence. In Gated mode, the sequence is always completed after the gate stop signal.

In case you want to remove a step from the sequence table, use the following command:

MSEQuence:DELete <n>

Where <n> is the step number to be removed from the sequence. To wipe out the sequence table use the following command:

MSEQuence:DELete:ALL

CAUTION

MSEQ:DEL:ALL is destructive. Use this command with caution because it will completely and irreversibly erase the sequence table from the memory.

Sequence Advance Commands

The way the instrument advances through sequence links and loops and the source of the event causing sequence advance, can be specified by the user. Use the following commands to control how a single sequence advances through the sequence table steps:

SSEQuence:ADVance {AUTO | STEP | SINGle}

AUTO specifies continuous advance where the generator steps continuously to the end of the sequence table and repeats the sequence from the start. For example, if a sequence is made of three segments – 1, 2, and 3, and AUTO mode is used, the sequence will generate an infinite number of 1, 2, 3, 1, 2, 3, 1, 2, 3…waveforms. Of course, each link (segment) can be programmed with its associated loop (repeat) number. AUTO is the default sequence advance mode.

In **STEP** advance mode, the sequence is advanced to the next waveform only when a valid trigger is received. The output of the model 301/302 generates the first segment continuously until a trigger signal advances the sequence to the next segment. If repeats were selected for a segment, the loop counter is executed automatically.

In **SING** advance mode, the Model 301/302 idles between steps until a valid trigger signal is sensed. This mode operates in triggered mode only. An attempt to select the SING advance mode when the Model 301/302 is in continuous operating mode will generate an error. After trigger, the generator outputs one waveform cycle. Then, the output level idles at a DC level equal to the last point of the last generated waveform. If loops (repeats) were programmed, the output will repeat this segment for n times (repeat counter) automatically. Only after executing all of the programmed loops will the sequence step to the next assigned segment.

The query:

SSEQuence:ADVance?

Queries sequence advance mode and returns AUTO, STEP, or SING.

NOTE

Sequenced sequences operate in stepped mode only. Advance through the sequence table using internal or external triggers only.

Sequence Advance Source Commands

The user can program the event causing the sequence generator to advance to best match his application needs. In AUTO mode, the sequence is repeated continuously and there is no need to specify an advance source. In all other modes: STEP, and SING, the user must specify an advance source. Use the following commands to select the advance source.

SSEQuence:ADVance:SOURce {INTernal | EXTernal}

EXT is the default trigger source where triggers are applied to the front-panel trigger input. This input may be used as a stimulant for all

sequence advance modes. Before you start using this input, make sure that the trigger level and trigger slope are programmed correctly to match your external trigger signal.

INT specifies using the internal trigger generator as the sequence advance source. The internal trigger generator produces repetitive, continuous, and asynchronous trigger signals at intervals set by the user. This source can be selected if an external source is not available. Trigger intervals are programmable from 20μs to 1000s. The internal trigger source may be used to advance all sequence advance modes.

The query:

SSEQuence:ADVance:SOURce?

Queries the sequence advance source and returns INT or EXT.

Sequenced sequences advance through triggers only. Advance source may be selected from an internal trigger generator or from an external trigger source. Use the following command to select the advance source for the sequenced sequence macro table:

MSEQuence:ADVance:SOURce {INTernal | EXTernal}

EXT is the default trigger source where triggers are applied to the front-panel trigger input. Before you start using this input, make sure that the trigger level and trigger slope are programmed correctly to match your external trigger signal.

INT specifies using the internal trigger generator as the sequence advance source. The internal trigger generator produces repetitive, continuous, and asynchronous trigger signals at intervals set by the user. This source can be selected if an external source is not available. Trigger intervals are programmable from 20μs to 1000s.

The query:

MSEQuence:ADVance:SOURce?

queries the sequenced sequences advance source and returns INT or EXT.

Generating Sequenced Sequences with

Previous parts of this manual show how to create segments and then how to build a table that is using these segments to generate a sequence. There is an added capability in the Model 301/2 that takes you even further; It allows you to build up to 16 different sequences,

Sequences with WaveWiz

use each sequence individually or link them into a sequence. Below is an example of how to produce a sequence of sequences. Using this a model' it will be possible to use the 301/2 to it's maximum potential and generate highly complex waveforms

Managing Your Sequence Memory

By default the Model 301/2 is ready to accept and execute a single sequence. So if you generated a sequence table you do not need to define the sequence number you are programming. It is different when you intend to load more than one sequence because you now have to first turn on this feature and you also must define up front how many sequences you intend to use.

The reason why you must first define the number of sequences you intend to design is again finite memory size. As discussed before, the sequence memory is very similar to the waveform memory However, it stores tables of segment numbers and not waveform data. Although the table data consumes less memory space, it still has finite size. The Model 301/2 can generate a maximum of 4096 links so if you use just one sequence, you can use all of these 4096 links. If you use 2 sequences, the number of links (segments) per sequence is 2048, etc. The following lists the number of sequences and their associated number of links.

Sequences	Links
1	4096
2	2048
4	1024
8	512
16	256

For numbers of sequences not shown on the above list, use the next number shown that is higher than the number of sequences you intend to use. For example, if you want to use 5 sequences the maximum number of links is 512. For 10 sequences, the maximum number of links is 256.

Before starting, click on the Delete All Segments icon to clear the entire memory from previously loaded waveforms. Proceed using the following instructions:

1. From the Setup menu, select the Instrument Control Panel. On the output tab ensure that "arbitrary" is selected. Then click on the

Sequence tab to display sequence parameters and options. There are two items to select on this panel: 1) Turn the Multi Sequence function on and 2) Select the number of sequences you intend to program. This example will use 3 sequences so, according to the rules explained above, you'll need to select 4. After you complete your selection the Sequence panel should look exactly as shown below. (figure 3.26)

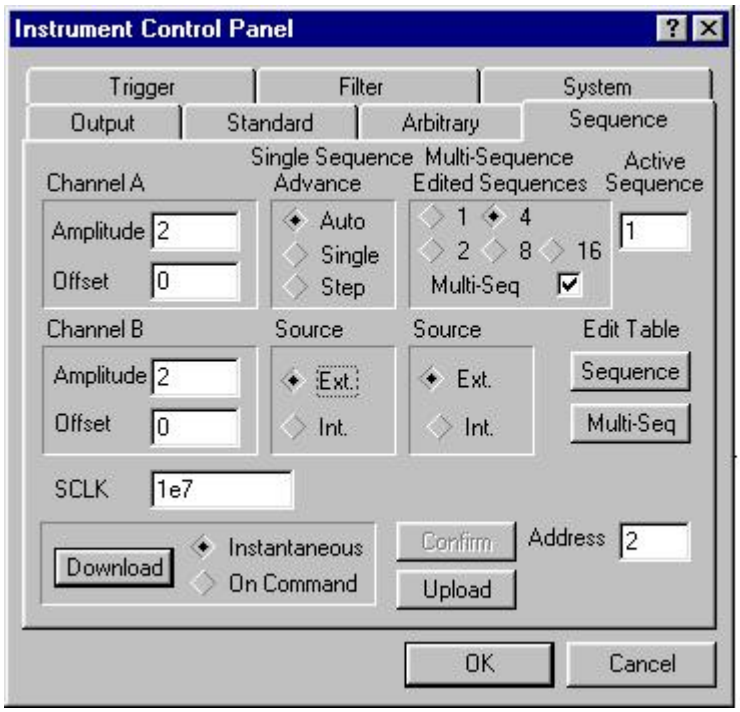

Figure 3.26 sequenced sequences

This tab shows that the Multi Sequence option is turned on and up to 4 different sequences can be programmed. Note the Active Sequence field; If you intend to generate a sequence table, the sequence you'll program is labeled "1". Also note the Edit Table buttons: Sequence and Multi-Seq; You'll need to use these buttons to edit your sequence tables.

1. Click OK to close the instrument Control Panel.

2. Using the information given earlier, create a few waveform segments that you want to use for this example.

3. Press the Sequence button on the sequence tab in the Instrument Control Panel. The Sequence Table editor will display. Notice the Active Sequence field on the top right. Sequences are represented by numerals from 1 through 16. The example below shows an example for programming sequence #2.

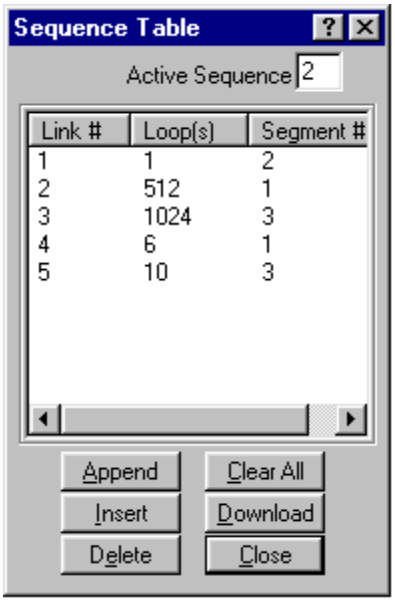

Figure 3.27 Sequence Table Editor

4. After you complete programming the table for each sequence, click Download to transfer the sequence table to the instrument. Click on close after you are done with programming all three sequences for this example.

NOTE

Now that you have programmed a few sequences, they can be used as individual sequences or placed in a Sequenced Sequences table to be used in one macro sequence. To use as individual sequences, simply select the required sequence number from the Active Sequence field on the Instrument Control Panel. Use the following procedure to generate a macro sequence.

5. Click on the Multi-Seq button from the Instrument Control Panel. The Multi Sequence Table editor will display.

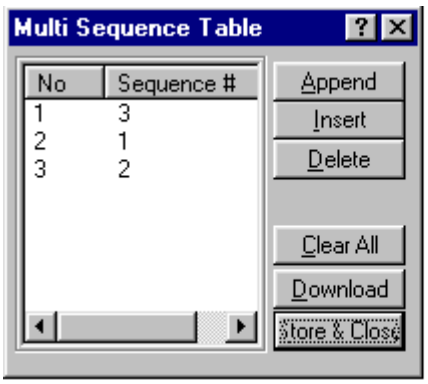

Figure 3.28a Multi Sequence Table Editor with 3 sequences

Modify the Multi Sequence Table as you like but remember that it was specified earlier in this example that you are going to use up to 4 sequences. The example above (Figure 3.28a)will generate sequences 3, 1 and 2 in this order.

Tip

Notice that sequences can not be repeated in this macro, so if you need to repeat a sequence more than once, specify a larger number of Edited Sequences and program a sequence as shown in the example below (Figure 3.28b)

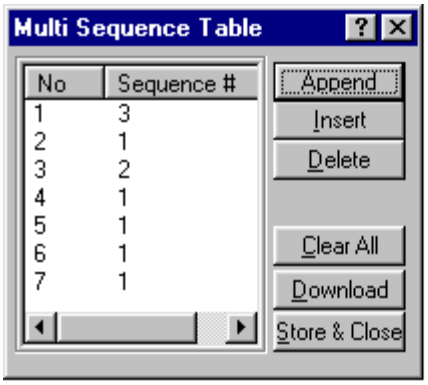

Figure 3.28b Multi Sequence Table Editor with 7 sequences and repeated sequences

After you have completed your sequence table, click Download to transfer the table to the Model 302, then click on Store & Close to remove the dialog box from the screen. To turn on the sequence generator, go back to the Instrument Control Panel, turn on the output

and select Sequenced output.

NOTE

The sequence generator goes through its steps in ascending order. In continuous mode, the sequence is repeated automatically after completing the last step. In Triggered mode, the output stops at the last point of the last waveform. In Gated mode, the sequence is always completed after the gate stop signal.

Adjusting Phase Offset Between Channels

The prime purpose of channel synchronization is to control the start phase in such a way that all channels start generating waveforms at the same instance, regardless of their respective waveform shape and frequency.

In general the initial start phase offset is around 0°. However, due to variations in circuit design and propagation delays, there is an unavoidable (but minimal) skew between the channels. The initial skew between channels is specified in Appendix A.

There are no internal provisions to correct skew between channels however, it can be easily corrected by adjusting the length of the cables that are connected to the output connectors. One meter of 50Ω coax cable amounts to about 2 ns of delay time. Use this general guideline to adjust the skew for your system. For example, if channel 2 lags 1.2 ns after channel 3, you have to delay the output of channel 3 by 1.2 ns. You'll have to extend the cable for channel 3 by roughly 0.6 meter to compensate for this skew.

Phase offsets are always referenced to channel A. Therefore, you can program phase offsets for channels B only. An attempt to program channel A with this parameter will result in an error message.

There are two ways to program phase offsets: 1) Using an angle and 2) Using waveform points. If you use angles to program your phase offset, you should first compute the equation given in Appendix A to determine your phase resolution and error. Using waveform points to specify phase offset is much easier because you have full control over waveform length and can easily determine the phase offset from the number of waveform points offset.

TIP

Phase offset between channels is programmable with resolution of 1 waveform point. The more points you have for your waveform, the better the phase offset resolution you can have. For example, for a 1,000-point waveform, your resolution is 1 / 1000 x 360 = 0.36°; for a

100,000-point waveform, the resolution is 0.036°.

Use the following command to define whether you are programming phase offsets in point or in angles:

PHASe:STEP {POINt | DEGree}

POIN defines phase offset in waveform points. Use DEG to program phase offsets in angles.

The query:

PHASe:STEP?

queries the units in which phase is programmed and returns POIN or DEG.

Use the following command to add phase offset to channel B:

PHASe:OFFSet <phase_offset>

Phase offset is programmed in degrees or waveform points.

The query:

PHASe:OFFSet?

queries the phase offset and returns a number in degrees or waveform points.

Using WaveWiz, Phase offset is set in the Output Tab of the Instrument Control Panel. The Coarse adjustment sets phase with a resolution to the nearest 8 points within the record. The Fine adjustment allows a resolution to 1 waveform point.

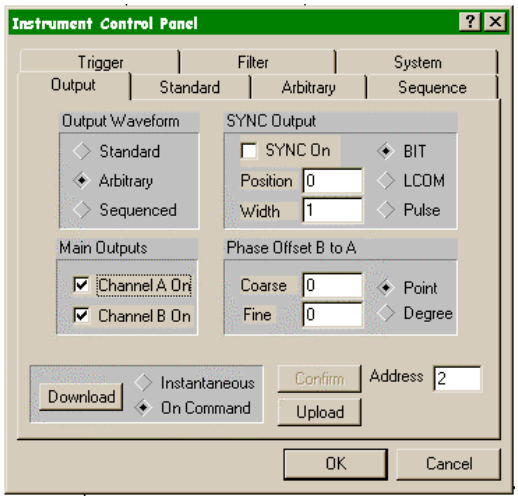

Figure 3.29 Channel to Channel Phase adjustment in WaveWiz

Amplitude Modulation Commands

The AM input is used for modulating the amplitude at the main output connector. The carrier signal is any continuous waveform, which was programmed for the output. The envelope signal is supplied from an external source to the AM input.

The command:

AM {OFF | ON}

controls the AM input where ON enables AM and OFF is the default.

The query:

AM?

queries the AM input state and returns “1” (ON) or “0” (OFF).

There is no specific control in WaveWiz to perform this function. In order to control AM, the SCPI command can be directly entered from the system tab in the Instrument Control Panel.

System-Related Commands

System-related commands are used to place the instrument in a known state, clear the instrument to its defaults, or query the generator for system errors or identification. The following is an overview of the system-related commands.

The query:

SYSTem:ERRor?

reads one error from the error queue. Up to 30 errors can be stored in the generator's error queue. Errors are retrieved in first-in-first-out (FIFO) order. The first error returned is the first error that was stored. When all errors have been read from the queue, the generator returns +0, "No error".

If more than 30 errors have occurred, the last error stored in the queue (the most current error) is replaced with -350,"Too many errors". No additional errors are stored until all errors have been removed from the queue. The error queue is cleared only when power is cycled off or after the execution of a *CLS command. The *RST command does not clear the error queue.

The query:

SYST:ERRor?

queries the system error queue and returns a string with the following format: -102,"Syntax error". A complete list of errors that can be detected by the generator is given in Chapter 4, SCPI Command Reference Guide.

The query:

SYSTem:VERSion?

queries the generator to determine the present SCPI revision and returns a string similar to "1993.0"

The query:

*IDN?

reads the generator's identification string. The generator returns four fields separated by commas. The first field is the manufacturer's name, the second field is the model number, the third field is not used (always "0") and the fourth field is the firmware revision number.

The command returns "Wavetek,301/302,0,1.0".

The commands:

RESet
*RST

reset the generator to its default state. The *RST and RES commands have no effect on status registers or SCPI command set.

The query:

*OPT?

queries the waveform memory length installed in the 301/302. The response is “0” for no option and “1" for 16 Meg.

SCPI Commands from WaveWiz

SCPI commands can be directly sent to the 301/302 from WaveWiz. Select the Command Editor in the System Menu and enter the

commands in the blank text box. Complete the command transmission by clicking on the download button. You may also send queries and watch the response in the Response List field. The command editor is very useful while developing your own application. Build your confidence or test various commands using the command editor. This way you can assure that commands or syntax that you use in your application will respond exactly the same way as it responds to the editor commands.

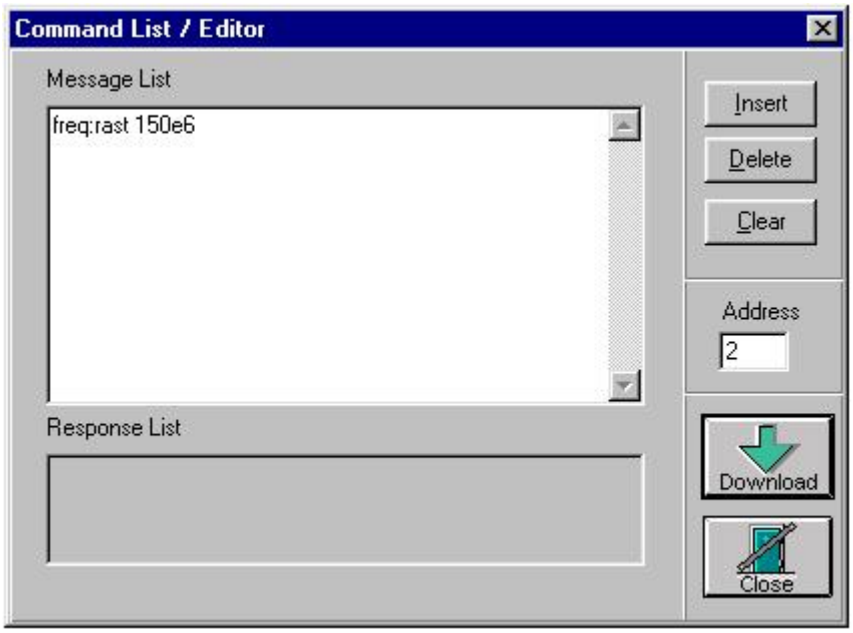

Figure 3.30 Entering SCPI commands direct from WaveWiz

SCPI COMMAND REFERENCE

Introduction

This Sub-Section lists and describes the set of SCPI-compatible remote commands used to operate the 301/302. To provide familiar formatting for users who have previously used the SCPI reference documentation, the command descriptions are dealt with in a similar manner. In particular, each sub-system's documentation starts with a short description, followed by a table showing the complete set of commands in the sub-system; finally the effects of individual keywords and parameters are described. Complete listing of all commands used for programming the Model 301/302 is given in Table 4.1.

SCPI Syntax and Styles

Where possible the syntax and styles used in this section follow those defined by the SCPI consortium. The commands on the following pages are broken into three columns; the KEYWORD, the PARAMETER FORM, and any NOTES.

The KEYWORD column provides the name of the command. The actual command consists of one or more keywords since SCPI commands are based on a hierarchical structure, also known as the tree system. Square brackets ([ ]) are used to enclose a **keyword** that is optional when programming the command; that is, the 302 will process the command to have the same effect whether the optional node is omitted by the programmer or not. Letter case in tables is used to differentiate between the accepted short form (upper case) and the long form (upper and lower case).

The PARAMETER FORM column indicates the number and order of parameter in a command and their legal value. Parameter types are distinguished by enclosing the type in angle brackets (< >). If **parameter** form is enclosed by square brackets ([ ]) these are then optional (care must be taken to ensure that optional parameters are consistent with the intention of the associated keywords). The vertical bar (|) can be read as "or" and is used to separate alternative parameter options.

Querying Parameter Setting

Query the current value of most parameters by adding a question mark (?) to the command. For example, the following command sets the output function to square:

SOUR:FUNC:SHAP SQR

Query the output function by executing:

SOUR:FUNC:SHAP?

Query Response Format

The response to a query depends on the format of the command. In general, a response to a query contains current values or settings of the generator. Commands that set values can be queried for their current value. Commands that set modes of operation can be queried for their current mode. IEEE-STD-488.2 common queries generate responses, which are common to all IEEE-STD-488.2 compatible instruments.

IEEE-STD-488.2 Common Commands

The IEEE-STD-488.2 standard defines a set of common commands that perform functions like reset, trigger and status operations. Common commands begin with an asterisk (*), are four to five characters in length, and may include one or more parameters. The command keyword is separated from the first parameter by a blank space. Use a semicolon (;) to separate multiple commands as shown below:

*RST; *STB?; *IDN?

Table 4-1. Model 301/302 SCPI Commands List Summary

Keyword	Parameter Form (Default in Bold)	Notes
:FORMat		
:BORDer	**NORMal** | SWAPped	
:INSTRument		
:SELect	**1** | 2	
:OUTPut		
[:STATe]	**OFF** | ON	
:MODE	**NORMal** | AUXiliary	
:FILTer		
[:LPASs]		
:FREQuency	**150M** | 10M | 5M | 2.5M | 800K	
[:STATe]	**OFF** | ON	
:SYNC		
[:STATe]	**OFF** | ON	
:SOURce	**BIT** | LCOMplete | PULSe	
:POSition		
[:POINt]	(**0**;0;4194304)	4 Meg memory
[:POINt]	(**0**;0;16777216)	16 Meg memory

:WIDTh	(1,1,99)	

Table 4-1. Model 301/302 SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	Notes
[:SOURce]		
:APPLy		
:SINusoid	<freq>,<ampl>,<offs>,<phas>	
:TRIangle	<freq>,<ampl>,<offs>,<phas>	
:SQUare	<freq>,<ampl>,<offs>,<duty_cycle>	
:PULSe	<freq>,<ampl>,<offs>,<delay>,<rise>,<high>,<fall>	
:RAMP	<freq>,<ampl>,<offs>,<delay>,<rise>,<fall>	
:SINC	<freq>,<ampl>,<offs>, <n_cycle>	
: GAUSsian	<freq>,<ampl>,<offs>,<exp>	
: EXPonential	<freq>,<ampl>,<offs>,<exp>	
: DC	<%_ampl>	
: USER	<seg#>,<sclk>,<ampl>,<offs>	
:FREQuency		
[:CW|:FIXed]	(**1e6**; 100e-6; 150e6) | MINimum | MAXimum	
: RASTer	(**10e6**; 100e-3; 300e6) | MINimum | MAXimum	
:SOURce	EXTernal | **INTernal**	
:VOLTage		
[:LEVel]		
[:IMMediate]		
[:AMPLitude]	(**2.000**;10E-3;5.000) | MINimum | MAXimum	
:OFFSet	(**0**;-2.5;+2.5)	
:FUNCtion		
:MODE	**FIXed** | USER | SEQuence	
:SHAPe	**SINusoid** | TRIangle | SQUare | PULSe | RAMP | SINC | EXPonential | GAUSsian | DC	
:SINusoid		
:PHASe	(**0**;0;360)	
:TRIangle		
:PHASe	(**0**;0;360)	
:SQUare		
:DCYCle	(**50**;1;99)	

Table 4-1. Model 301/302 SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	Notes
:PULSe		
:DELay	(**10**;0;99.9)	
:WIDth	(**10**;0;99.9)	
:TRANsition		
[:LEADing]	(**10**;0;99.9)	
:TRAiling	(**10**;0;99.9)	
:RAMP		
:DELay	(**0**;0;99.9)	
:TRANsition		
[:LEADing]	(6**0**;0;99.9)	
:TRAiling	(**30**;0;99.9)	
:GAUSsian		
:EXPonent	(2**0**;10;200)	
:SINC		
:NCYCle	(**10**;4;100)	
:EXPonential		
:EXPonent	(**1**;-20.00;20.00)	
:DC		
[:VOLTage]		
[:IMMediate]		
[:AMPLitude]	(**100**;-100;100)	
:AM		
[:STATe]	**OFF** | ON	
:PHASe		
:STEP	**POINt** | DEGree	
:OFFset		
[:COURse]	(0,0,360) in degrees, or (0,0,n) in waveform points	8-point increments
:FINE	(0,0,360) in degrees, or (0,0, 131072) in points	1-point increments
:TRACe		
[:DATA]	<arbitrary_block>	
DEFine	(1;1;4096),(16;16;4193304)	Even number, 4 Meg memory, divisible by 8
DEFine	(1;1;4096),(16;16;16776216)	Even number, 16 Meg memory, divisible by 8
:DELete		
[:NAME]	(1;1;4096)	
:ALL		

:SELect	(**1**;1;4096)	

Table 4-1. Model 301/302 SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	Notes
:DMA		
[:STATe]	**[OFF]** | ON	OFF is automatic
:SEQuence		
:MODE	**SSEQuence** | MSEQuence	
:SSEQuence		
:ADVance	**AUTOmatic** | STEP | SINGle	
:SOURce	**EXTernal** | INTernal	
:DEFine	(1;1;4096),(1;1;4096),(1;1;1E6)	
:SELect	(**1**;1;16)	
:DELete		
[:NAME]	(**1**;1;4096)	
:ALL		
:MSEQuence		
:ADVance	**AUTOmatic** | STEP | SINGle	
:SOURce	**EXTernal** | INTernal	
:DEFine	(1;1;4096),(1;1;4096),(1;1;1E6)	
:SIZE	**1** | 2 | 4 | 8 | 16	
:DELete		
[:NAME]	**1** | 2 | 4 | 8 | 16	
:ALL		
:INITiate		
[:IMMediately]		
:CONTinuous	OFF | **ON**	
:TRIGger		
:BURSt		
[:STATe]	**OFF** | ON	
:COUNt	(**1**;1;1E6)	
:LEVel	(**1.6**;-10.00;+10.00)	
:SOURce		
:ADVance	**EXTernal** | INTernal	
:GATE		
[:STATe]	**OFF** | ON | 0 | 1	

Table 4-1. Model 301/302 SCPI Commands List Summary (continued)

Keyword	Parameter Form (Default in Bold)	Notes
:SLOPe	**POSitive** | NEGative	
:LEVel	**(1.6;+10V;-10V)**	
:TIMer	(**1e-3**;20e-6;999)	
[:IMMediate]		
:RESet		
:SYSTem		
:ERRor?		Query only
:VERSion?		Query only
:TEST		
[:ALL]?		Query only
*CLS		
*ESE	(**0**;0;255)	
*OPC		
*RST		
*SRE	(**0**;0;255)	
*TRG		
*ESE?		Query only
*ESR?		Query only
*IDN?		Query only
*OPC?		Query only
*SRE?		Query only
*STB?		Query only
*TST?		Query only

SOURce Subsystem

This subsystem is used to control output functions, shape and parameters, frequency, amplitude and amplitude modulation, and filter type. Optional nodes were omitted from these commands. Factory defaults after *RST are shown in bold typeface. Parameter low and high limits are given where applicable.

Keyword	Parameter Form	**Default,**Low Limit,High Limit
[:SOURce]		
:AM (?)	{OFF|ON|0|1}	**OFF**
:APPLy (?)		
:SINusoid (?)	{<freq>,<ampl>,<offs>,<phase>}	
:TRIangle (?)	{<freq>,<ampl>,<offs>,<phase>}	
:SQUare (?)	{<freq>,<ampl>,<offs>,<duty_cycle>}	
:PULSe (?)	{<freq>,<ampl>,<offs>,<delay>,<rise>,<high>,<fall>}	
:RAMP (?)	{<freq>,<ampl>,<offs>,<delay>,<rise>,<fall>}	
:SINC (?)	{<freq>,<ampl>,<offs>,<N_cycles>}	
:EXPonential (?)	{<freq>,<ampl>,<offs>,<exp>}	
:GAUSsian (?)	{<freq>,<ampl>,<offs>,<exp>}	
:DC (?)	{<%_ampl>}	
:USER (?)	{<seg#>,<sclk>,<ampl>,<offs>}	
:FREQuency (?)	{<freq>|MINimum|MAXimum}	**1e6**,100e-6,150e6
:RASTer (?)	{<sclk>|MINimum|MAXimum}	**10e6**,100e-3,300e6
:SOURce (?)	{EXTernal|INTernal}	**INTernal**
:FUNCTion		
:MODE (?)	{FIXed|USER|SEQuence}	**FIXed**
:SHAPe (?)	{SINusoid|TRIangle|SQUare|PULSe| RAMP|SINC|EXPonential|GAUSsian|DC}	**SINusoid**
:PHASe:STEP (?)	{POINt|DEGRee}	**POINt**
:OFFSet (?)	<course_offs>	**0**,0,n
:FINE (?)	<fine_offs>	**0**,0,131072
:VOLTage (?)	{<ampl>|MINimum|MAXimum}	**2**,10e-3,5
:OFFSet (?)	<offs>	**0**,-2.5,2.5
:SINusoid		
:PHASe (?)	<phase>	**0**,0,360
:TRIangle		
:PHASe (?)	<phase>	**0**,0,360
:SQUare		
:DCYCle (?)	<duty_cycle>	**50**,1,99
:PULSe		
:DELay (?)	<delay>	**10**,0,99.9
:WIDTh (?)	<pulse_width>	**10**,0,99.9
:TRANsition (?)	<rise>	**10**,0,99.9
:TRAiling (?)	<fall>	**10**,0,99.9
:RAMP		
:DELay (?)	<delay>	**0**,0,99.9
:TRANsition (?)	<rise>	**60**,0,99.9
:TRAiling (?)	<fall>	**30**,0,99.9
:SINC		
:NCYCle (?)	N_cycles>	**10**,4,100
:GAUSsian		
:EXPonent (?)	<exp>	**20**,10,200
:EXPonential		
:EXPonent (?)	<exp>	**-20**,-100,+100

`:DC (?)` `<%_amplitude>` **100**,-100,+100

AM OFF | ON | 0 | 1

Purpose
This command turns the AM function on and off

- ON or 1 will set the AM on
- OFF or 0 will set the AM off

AM?

Response
The 302 will return 1 if the AM is on, or 0 if the AM is off.

APPLy:SINusoid <freq>,<ampl>,<offs>,<phase>

Purpose
This command is a high-level command that programs the 302 to output sine waveform along with its associated parameters

- <freq> numeric which sets the output frequency
- <ampl> numeric which sets the output amplitude
- <offs> numeric which sets the output offset
- <phase> numeric which sets the output start phase

APPLy:SINusoid?

Response
The 302 will return four numerics which represent in order <freq>,<ampl>,<offs>,<phase>.

APPLy:TRIangle <freq>,<ampl>,<offs>,<phase>

Purpose
This command is a high-level command that programs the 302 to output triangular waveform along with its associated parameters

- <freq> numeric which sets the output frequency
- <ampl> numeric which sets the output amplitude
- <offs> numeric which sets the output offset
- <phase> numeric which sets the output start phase

APPLy:TRIangle?

Response to query version
The 302 will return four numerics which represent in order <freq>, <ampl>,<offs>,<phase>.

APPLy:SQUare <freq>,<ampl>,<offs>,<duty_cycle>

Purpose
This command is a high-level command that programs the 302 to output square waveform along with its associated parameters

- <freq> numeric which sets the output frequency
- <ampl> numeric which sets the output amplitude
- <offs> numeric which sets the output offset

- <duty_cycle> numeric which sets the squarewave duty cycle

APPLy:SQUare?

Response

The 302 will return five numerics which represent in order <freq>, <ampl>,<offs>,<duty_cycle>.

APPLy:PULSe <freq>,<ampl>,<offs>,<delay>,<rise>,<high>,<fall>

Purpose

This command is a high-level command that programs the 302 to output pulse waveform along with its associated parameters

- <freq> numeric which sets the output frequency
- <ampl> numeric which sets the output amplitude
- <offs> numeric which sets the output offset
- <delay> numeric which sets the delay to the pulse rise transition
- <rise> numeric which sets the pulse rise time
- <high> numeric which sets the pulse high time
- <fall> numeric which sets the pulse fall time

APPLy:PULSe?

Response

The 302 will return seven numerics which represent in order
<freq>,<ampl>,<offs>,<delay>,<rise>,<high>,<fall>.

APPLy:RAMP <freq>,<ampl>,<offs>,<delay>,<rise>,<fall>

Purpose

This command is a high-level command that programs the 302 to output ramp waveform along with its associated parameters

- <freq> numeric which sets the output frequency
- <ampl> numeric which sets the output amplitude
- <offs> numeric which sets the output offset
- <delay> numeric which sets the delay to the pulse rise transition
- <rise> numeric which sets the pulse rise time
- <fall> numeric which sets the pulse fall time

APPLy:RAMP?

Response

The 302 will return six numerics which represent in order <freq>, <ampl>,<offs>,<delay>,<rise>,<fall>.

APPLy:SINC <freq>,<ampl>,<offs>,<N_cycles>

Purpose

This command is a high-level command that programs the 302 to output sinc waveform along with its associated parameters

- <freq> numeric which sets the output frequency
- <ampl> numeric which sets the output amplitude

- <offs> numeric which sets the output offset
- <N_cycles> numeric which sets the number of zero crossing

APPLy:SINC?

Response
The 302 will return four numerics which represent in order <freq>, <ampl>,<offs>,<N_cycles>.

APPLy:EXPonential <freq>,<ampl>,<offs>,<exp>

Purpose
This command is a high-level command that programs the 302 to output exponential waveform along with its associated parameters

- <freq> numeric which sets the output frequency
- <ampl> numeric which sets the output amplitude
- <offs> numeric which sets the output offset
- <exp> numeric which sets the exponent value

APPLy:EXPonential?

Response
The 302 will return four numerics which represent in order <freq>, <ampl>,<offs>,<exp>.

APPLy:GAUSsian <freq>,<ampl>,<offs>,<exp>

Purpose
This command is a high-level command that programs the 302 to output gaussian waveform along with its associated parameters

- <freq> numeric which sets the output frequency
- <ampl> numeric which sets the output amplitude
- <offs> numeric which sets the output offset
- <exp> numeric which sets the exponent value

APPLy:GAUSsian?

Response
The 302 will return four numerics which represent in order <freq>, <ampl>,<offs>,<exp>.

APPLy:DC <%_ampl>

Purpose
This command is a high-level command that programs the 302 to output DC level along with its associated parameter

- <%_ampl> numeric which sets the output level as percentage of the amplitude setting

APPLy:DC?

Response
The 302 will return one numeric which represents <%_ampl>

APPLy:USER <seg# >,<sclk>,<ampl>,<offs>

Purpose

This command is a high-level command that programs the 302 to output user-defined waveform along with its associated parameters

- <seg# > selects the active segment
- <sclk> numeric which sets the sample clock frequency
- <ampl> numeric which sets the output amplitude
- <offs> numeric which sets the output offset

APPLy:USER?

Response
The 302 will return <seg#>,<sclk>, <ampl>,<offs>

FREQuency <freq> | MINimum | MAXimum

Purpose
This command modifies the frequency of the standard waveform. It has no affect on arbitrary waveforms.

- <sclk> numeric value that sets the waveform frequency
- <MINimum> sets the waveform frequency to its lowest value
- <MAXimum> sets the waveform frequency to its highest value

FREQuency?

Response
The 302 will return the present frequency value. The returned value will be in standard scientific format (for example: 100mHz would be returned as 100E-3 – positive numbers are unsigned).

FREQuency:RASTer <sclk> | MINimum | MAXimum

Purpose
This command modifies the sample clock frequency of the arbitrary waveform. It has no affect on standard waveforms.

- <sclk> numeric value that sets the sample clock frequency
- <MINimum> sets the sample clock frequency to its lowest value
- <MAXimum> sets the sample clock frequency to its highest value

FREQuency:RASTer ?

Response
The 302 will return the present sample clock frequency value. The returned value will be in standard scientific format (for example: 100MHz would be returned as 100E6 – positive numbers are unsigned).

FREQuency:RASTer:SOURce EXTernal | INTernal

Purpose

This command selects the source of the sample clock generator. This command affects both the standard and the arbitrary waveforms.

- <EXTernal> selects an external source
- <INTernal> selects the internal source

FREQuency:RASTer:SOURce?

Response

The 302 will return EXT if an external source is selected, or INT if the internal source is selected.

FUNCTion:MODE FIXed | USER | SEQuence

Purpose

This command defines the type of waveform that will be available at the output connector.

- <FIXed> selects standard waveforms
- <USER> selects arbitrary waveforms
- <SEQuence> selects sequenced waveforms

FUNCTion:MODE?

Response

The 302 will return FIX, USER, or SEQ depending on the present 302 setting.

FUNCtion:SHAPe SINusoid | TRIangle | SQUare | PULSe | RAMP | SINC | EXPonential | GAUSsian | DC}

Purpose

This command defines the shape of waveform that will be available at the output connector. This command has no affect if present 302 setting is USER or SEQ.

- <SINusoid> selects sine waveform
- <TRIangle> selects triangular waveform
- <SQUare> selects square waveform
- <PULSe> selects pulse waveform
- <RAMP> selects ramp waveform
- <SINC> selects sinc waveform
- <EXPonential> selects exponential waveform
- <GAUSsian selects gaussian waveform
- <DC> selects dc waveform

FUNCtion:SHAPe?

Response

The 302 will return SIN, TRI, SQU, PULS, RAMP, SINC, EXP, GAUS, or DC depending on the present 302 setting.

PHASe:STEP POINt | DEGRee

Purpose

This command defines which units will be used when programming the start phase offset between channels 1 and 2 waveforms.

- <POINt> selects waveform point units
- <DEGRee> selects degree units

PHASe:STEP?

Response to query version

The 302 will return the present POIN, or DEGR depending on the current 302 setting.

PHASe:OFFSet <course_offs>

Purpose

This command programs the start phase offset between channels 1 and 2. Phase may be programmed in units of degrees, or in units of waveform points, depending on the PHAS:STEP selection. Phase offset resolution when using this command is 8 points and maximum phase offset is limited by the length of the waveform.

- <course_offs> numeric value that sets the phase offset between the channels

PHASe:OFFSet?

Response to query version

The 302 will return the present course phase offset value in units of degrees, or units of waveform points, depending on the PHAS:STEP setting.

PHASe:OFFSet:FINE <fine_offs>

Purpose

This command programs the start phase offset between channels 1 and 2. Phase offset resolution when using this command is 1 point and maximum phase offset is limited by 128k points.

- <fine _offs> numeric value that sets the phase offset between the channels

PHASe:OFFSet:FINE?

Response

The 302 will return the present fine phase offset value.

VOLTage <ampl> | MINimum | MAXimum

Purpose

This command programs the peak to peak amplitude of the output waveform. The amplitude is calibrated when the source impedance is 50Ω.

- <amp> numeric value that sets the amplitude
- <MINimum> sets the amplitude to its lowest value
- <MAXimum> sets the amplitude to its highest value

VOLTage?

Response

The 302 will return the present amplitude value. The returned value will be in standard scientific format (for example: 100mV would be returned as 100E-3 – positive numbers are unsigned).

VOLTage:OFFSet <offs>

Purpose

This command programs the amplitude offset of the output waveform. The offset is calibrated when the source impedance is 50Ω.

- <offs> numeric value that sets the amplitude offset

VOLTage:OFFSet ?

Response

The 302 will return the present offset value. The returned value will be in standard scientific format (for example: 100mV would be returned as 100E-3 – positive numbers are unsigned).

SINusoid:PHASe <phase>

Purpose

This command programs start phase of the standard sine waveform. This command has no affect on arbitrary waveforms.

- <phase> numeric value that sets the start phase

SINusoid:PHASe?

Response

The 302 will return the present start phase value.

TRIangle:PHASe <phase>

Purpose

This command programs start phase of the standard triangular waveform. This command has no affect on arbitrary waveforms.

- <phase> numeric value that sets the start phase

TRIangle:PHASe?

Response

The 302 will return the present start phase value.

SQUare:DCYCle <duty_cycle>

Purpose

This command programs duty cycle of the standard square waveform. This command has no affect on arbitrary waveforms.

- <duty_cycle> numeric value that sets the duty cycle value

SQUare:DCYCle?

Response

The 302 will return the present duty cycle value.

PULSe:DELay <delay>

Purpose

This command programs delay of the standard pulse waveform. This command has no affect on arbitrary waveforms.

- <delay> numeric value that sets the delay parameter

PULSe:DELay?

Response

The 302 will return the present delay value.

PULSe:WIDTh(?)<pulse_width>

Purpose

This command programs pulse high portion of the standard pulse waveform. This command has no affect on arbitrary waveforms.

- <pulse_width> numeric value that sets the high time parameter

PULSe:WIDTh?

Response

The 302 will return the present width value.

PULSe:TRANsition <rise>

Purpose

This command programs pulse transition from low to high of the standard pulse waveform. This command has no affect on arbitrary waveforms.

- <rise> numeric value that sets the rise time parameter

PULSe:TRANsition?

Response

The 302 will return the present rise time value.

PULSe:TRANsition:TRAiling(?)<fall>

Purpose

This command programs pulse transition from high to low of the standard pulse waveform. This command has no affect on arbitrary waveforms.

- <fall> numeric value that sets the fall time parameter

PULSe:TRANsition:TRAiling?

Response

The 302 will return the present fall time value.

RAMP:DELay <delay>

Purpose

This command programs delay of the standard ramp waveform. This command has no affect on arbitrary waveforms.

- <delay> numeric value that sets the delay parameter

RAMP:DELay?

Response to query version

The 302 will return the present delay value.

RAMP:TRANsition <rise>

Purpose

This command programs ramp transition from low to high of the standard ramp waveform. This command has no affect on arbitrary waveforms.

- <rise> numeric value that sets the rise time parameter

RAMP:TRANsition?

Response

The 302 will return the present rise time value.

RAMP:TRANsition:TRAiling <fall>

Purpose

This command programs ramp transition from high to low of the standard ramp waveform. This command has no affect on arbitrary waveforms.

- <fall> numeric value that sets the fall time parameter

RAMP:TRANsition:TRAiling?

Response

The 302 will return the present fall time value.

SINC:NCYCle <N_cycles>

Purpose

This command programs the number of “0-crossings” of the standard SINC pulse waveform. This command has no affect on arbitrary waveforms.

- <N_cycle> numeric value that sets the number of zero-crossings parameter

SINC:NCYCle?

Response

The 302 will return the present number of zero-crossing value.

GAUSsian:EXPonent <exp>

Purpose

This command programs the exponent for the standard gaussian pulse waveform. This command has no affect on arbitrary waveforms.

- <exp > numeric value that sets the exponent parameter

GAUSsian:EXPonent?

Response
The 302 will return the present exponent value.

EXPonential:EXPonent <exp>

Purpose
This command programs the exponent for the standard exponential waveform. This command has no affect on arbitrary waveforms.

- <exp > numeric value that sets the exponent parameter

EXPonential:EXPonent?

Response
The 302 will return the present exponent value.

DC <%_amplitude>

Purpose
This command programs the amplitude of the standard DC waveform. This command has no affect on arbitrary waveforms.

- <%_amplitude > numeric value that sets the dc level as percentage of the programmed amplitude setting

DC?

Response
The 302 will return the present dc value.

OUTPut Subsystem

This subsystem controls the characteristics of the output. It controls filter type and filter cutoff frequency. It is also used to control the sync output, source and position. Optional nodes were omitted from these commands. Factory defaults after *RST are shown in bold typeface. Parameter low and high limits are given where applicable.

Keyword	Parameter Form	**Default,**Low Limit,High Limit
:OUTPu	OFF|ON|0|1	**OFF**
:FILTer	OFF|ON|0|1	**OFF**
:FREQuency	150M|10M|5M|2.5M|800K	
:MODE	NORMal|AUXiliary	**NORMal**
:SYNC	OFF|ON|0|1	**OFF**
:SOURce	BIT|LCOMplete|PULSe	**BIT**
:POSition	<position>	**0**,0,4M/16M
:WIDTh	<width>	**1**,1,99

OUTPut OFF | ON | 0 | 1

Purpose

This command will turn the 302 output on and off.

- ON or 1 will set the output on
- OFF or 0 will set the output off

OUTPut?

Response

The 302 will return 1 if the output is on, or 0 if the output is off.

OUTPut:FILTer OFF | ON | 0 | 1

Purpose

This command will connect and disconnect filters to the 302 output.

- ON or 1 will connect filters
- OFF or 0 will disconnect filters

OUTPut:FILTer?

Response

The 302 will return 1 if filters are connected to the output, or 0 if filters are not connected to the output.

OUTPut:FILTer:FREQuency 150M | 10M | 5M | 2.5M | 800K

Purpose

This command will select which filter is connected to the 302 output.

- 150M will connect 150 MHz low pass elliptic filter
- 10M will connect 10 MHz low pass elliptic filter

- 5M will connect 5 MHz low pass elliptic filter
- 2.5M will connect 2.5 MHz low pass elliptic filter
- 800K will connect 800 KHz low pass elliptic filter

OUTPut:FILTer:FREQuency?

Response

The 302 will return 150M, 10M, 5M, 2.5M, 800K depending on the type of filter presently connected to the output.

OUTPut:FILTer:MODE NORMal | AUXiliary

Purpose

This command will route the filters to either the main outputs, or the auxiliary outputs.

- NORMal will route the filters to the main output connectors
- AUXiliary will route the filters to the auxiliary output connectors

OUTPut:FILTER:MODE?

Response

The 302 will return NORM if the filters are presently connected to the main outputs, or AUX if the filters are connected to the auxiliary outputs.

OUTPut:SYNC OFF | ON | 0 | 1

Purpose

This command will turn the 302 SYNC output on and off.

- ON or 1 will set the SYNC output on
- OFF or 0 will set the SYNC output off

OUTPut:SYNC?

Response

The 302 will return 1 if the SYNC output is on, or 0 if the SYNC output is off.

OUTPut:SYNC:SOURce BIT | LCOMplete | PULSe

Purpose

This command will select 302 SYNC validator.

- BIT will set the SYNC to output a narrow pulse
- LCOMplete will set the SYNC to transition high at the beginning of the sequence and low a the end of the sequence
- PULSe will enable pulse width control over the SYNC pulse

OUTPut:SYNC:SOURce?

Response

The 302 will return BIT, LCOM, or PULS depending on the present setting of the SYNC source.

OUTPut:SYNC:POSition <position>

Purpose

This command will program the 302 SYNC position. This command is active in arbitrary (USER) mode only.

- <position> will set the SYNC position in waveform points

OUTPut:SYNC:POSition?

Response

The 302 will return the present SYNC position value.

OUTPut:SYNC:WIDTh <width>

Purpose

This command will program the width of the SYNC pulse. This command is active only after PULSe was selected as the SYNC source.

- <width> will set the SYNC width

OUTPut:SYNC:WIDTh?

Response

The 302 will return the present SYNC width value

FORMat Subsystem

The FORMat subsystem sets a data format for transferring array information. This data format is used for commands that are specifically designated to be affected by the FORMat subsystem. Factory defaults after *RST are shown in bold typeface. Parameter low and high limits are given where applicable.

Keyword	Parameter Form	**Default,**Low Limit,High Limit
:FORMat		
:BORDer	NORMal|SWAPped	**NORMal**

FORMat:BORDer NORMal | SWAPped

Purpose
This command will set the byte order for the trace command.

- NORMal will set low-high byte order
- SWAPped will set high-low byte order

FORMat:BORDer?

Response
The 302 will return NORM, or SWAP depending on the present byte order setting.

INSTrument Subsystem

A dual channel arbitrary waveform generator is considered as two logical instruments. The INSTrument subsystem provides a mechanism to identify and select instrument channels. Factory defaults after *RST are shown in bold typeface. Parameter low and high limits are given where applicable.

Keyword	Parameter Form	**Default,**Low Limit,High Limit
`:INSTrument`	`1|2`	**1**

INSTrument 1 | 2

Purpose

This command will set the active channel. Subsequent commands affect the selected channel only.

- 1 will set channel 1 active
- 2 will set channel 2 active

INSTrument?

Response

The 302 will return 1, or 2 depending on the present active channel setting.

Trigger Subsystem

The TRIGger subsystem is used to synchronize device actions with external events. These commands control the trigger modes of the Model 301/302. The Model 301/302 can be placed in Triggered, Gated or Burst mode. Trigger source is selectable from an external source, an internal trigger generator or a software trigger. Optional nodes were omitted from these commands. Factory defaults after *RST are shown in bold typeface. Parameter low and high limits are given where applicable.

Keyword	Parameter Form	**Default,**Low Limit,High Limit
:INITiate		
:CONTinuous	OFF|ON|0|1	**ON**
:TRIGger		
:BURSt	OFF|ON|0|1	**OFF**
:COUNt	<count>	**1**,1,1e6
:GATE	OFF|ON|0|1	**OFF**
:LEVel	<level>	**1.6**,-10,10
:SLOPe	POSitive|NEGative	**POSitive**
:SOURce		
:ADVance	EXTernal|INTernal	**EXTernal**
:TIMer	<period>	**1**,20e-6,999
:IMMediate		
*TRG		

INITiate:CONTinuous OFF | ON | 0 | 1

Purpose

This command will set the output in continuous operation and interrupted operation. The trigger subsystem commands will affect the 302 only after it will be set to interrupted operation.

- ON or 1 will set the interrupted mode
- OFF or 0 will set the continuous mode

INITiate:CONTinuous?

Response

The 302 will return 1 if the output is interrupted, or 0 if the output is continuous.

TRIGger:BURSt OFF | ON | 0 | 1

Purpose

This command will set the burst mode. This command will affect the 302 only after it will be set to interrupted operation.

- ON or 1 will set the burst mode on
- OFF or 0 will set the burst mode off

TRIGger:BURSt?

Response

The 302 will return 1 if the burst is on, or 0 if the burst is off.

TRIGger:COUNt <count>

Purpose

This command will set the burst counter.

- <count> numeric value that will set the count number

TRIGger:COUNt?

Response

The 302 will return the present count value.

TRIGger:GATE OFF | ON | 0 | 1

Purpose

This command will set the gate mode. This command will affect the 302 only after it will be set to interrupted operation.

- ON or 1 will set the gate mode on
- OFF or 0 will set the gate mode off

TRIGger:GATE?

Response

The 302 will return 1 if the gate is on, or 0 if the gate is off.

TRIGger:LEVel <level>

Purpose

This command will set the trigger level for the trigger input.

- <level> numeric value will set the trigger level

TRIGger:LEVel?

Response

The 302 will return the present trigger level value.

TRIGger:SLOPe POSitive | NEGative

Purpose

This command will set the edge sensitivity for the trigger input.

- <POSitive> will set the positive edge
- <NEGative> will set the negative edge

TRIGger:SLOPe?

Response

The 302 will return POS, or NEG depending on the present trigger setting.

TRIGger:SOURce:ADVance EXTernal | INTernal

Purpose

This command will set the advance source for the trigger mode.

- <EXTernal> will select the external input
- <INTernal > will select the internal trigger generator

TRIGger:SOURce:ADVance?

Response

The 302 will return EXT, or INT depending on the present trigger source setting.

TRIGger:TIMer <period>

Purpose

This command will set the period for the internal trigger generator.

- <period> numeric value will set the frequency of the internal trigger generator

TRIGger:TIMer?

Response

The 302 will return the present internal period value.

TRIGger:IMMediate

Purpose

This command will stimulate the 302 output once. This command will affect the 302 only after it will be set to interrupted operation.

*TRG

Purpose

This common command has the same affect as the TRIG:IMM command.

TRACe Subsystem

The TRACe subsystem contains commands, which allow definition of segments and their corresponding lengths, addition and deletion of segments, and the loading of waveform data. Sequence commands control segments link and loops. DMA command places the Model 301/302 in a special data transfer mode where the Model 301/302's message-based interface is bypassed and data is loaded directly from the data bus. Optional nodes were omitted from these commands. Defaults are shown in bold.

Keyword	Parameter Form	**Default,**Low Limit,High Limit
:DMA	OFF|ON|0|1	**OFF**
:TRACe	#<header><binary_block>	
:DEFine	<segment_number>,<length>	
:DELete	<segment_number>	
:DELete:ALL		
:SELect	<segment_number>	
:SEQuence		
:MODE	SSEQuence|MSEQuence	**SSEQuence**
:SSEQuence		
:ADVance	AUTOmatic|STEP|SINGle	**AUTOmatic**
:SOURce	EXTernal|INTernal	**EXTernal**
:DEFine	<step_#>,<segment_#>,<#_repeat>	
:DELete	<ssequence_# >	
:DELete:ALL		
:SELect	<ssequence_# >	
:MSEQuence		
:SIZE	<msequence_size>	
:ADVance		
:SOURce	EXTernal|INTernal	**EXTernal**
:DEFine	<step_#>,<ssequence_#>	
:DELete	<msequence_#>	
:DELete:ALL		

DMA [OFF] | ON | [0] | 1

Purpose

This command will set the DMA mode.

- ON or 1 will set the DMA mode on
- OFF is set automatically with the high byte's MSB set to "1". Sending OFF will not generate an error message

DMA?

Response

The 302 will return 0 if the DMA is off. This query cannot be used after sending DMA ON.

TRACe #<header><binary_block>

Purpose
This command will download waveform data to the 302 memory. The Loading Arbitrary Waveforms section of this manual descries how to use this command in greater details.

TRACe:DEFine <segment_number>,<length>

Purpose
This command will define waveform segments and their relative length. Waveform data can be loaded into segments only after using this command.

- <segment_number> numeric value will set the selected segment
- <length> numeric value will assign length to the above selected segment

TRACe:DELete <segment_number>

Purpose
This command will delete a segment.

- <segment_number> numeric value will select the segment number that will be deleted

TRACe:DELete:ALL

Purpose
This command will delete all segments and will clear the entire waveform memory.

TRACe:SELect <segment_number>

Purpose
This command will select the active waveform segment for the output.

- <segment_number> numeric value will set the active waveform segment number

TRACe:SELect?

Response
The 302 will return the active segment number.

SEQuence:MODE SSEQuence | MSEQuence

Purpose
This command will select the sequence mode.

- <SSEQuence> will select the single sequence mode
- <MSEQuence> will select the multi sequence mode

SEQuence:MODE?

Response
The 302 will return the SSEQ, or MSEQ depending on the present sequence mode setting.

SSEQuence:ADVance AUTOmatic | STEP | SINGle

Purpose
This command will select the single-sequence advance mode.

- <AUTOmatic> will set the automatic advance mode
- <STEP> will set the stepped advance mode
- <SINGle> will set the single advance mode

SSEQuence:ADVance?

Response

The 302 will return the AUTO, STEP, or SING depending on the present sequence advance mode setting.

SSEQuence:ADVance:SOURce EXTernal | INTernal

Purpose

This command will select the single-sequence advance source.

- <EXTernal> will set the external advance mode
- <INTernal> will set the internal advance mode

SSEQuence:ADVance:SOURce?

Response

The 302 will return the EXT, or INT depending on the present single-sequence advance source setting.

SSEQuence:DEFine <step_#>,<segment_#>,<#_repeat>

Purpose

This command will define single-sequence step.

- <step_#> numeric value will define the link number
- <segment_#> numeric value will select the segment for the above link
- <#_repeat> numeric value will define how many times the selected segment will loop

SSEQuence:DELete <ssequence_#>

Purpose

This command will delete a single sequence

SSEQuence:DELete:ALL

Purpose

This command will delete all sequences

SSEQuence:SELect <ssequence_#>

Purpose

This command will select the active sequence. You must use this command before you program this specific sequence. Also, by selecting this sequence active, the SYNC output is made associated with this sequence.

- <SSEQuence> numeric value will select the active sequence

SSEQuence:SELect?

Response

The 302 will return the present single-sequence value.

MSEQuence:SIZE(?)<msequence_size>

Purpose

This command will set the number of sequences to be used with the multi-sequence mode.

- <msequence_size> numeric value will select the number of sequences

MSEQuence:SIZE?

Response

The 302 will return the present multi-sequence size value.

MSEQuence:ADVance:SOURce EXTernal | INTernal

Purpose

This command will select the multi-sequence advance source.

- <EXTernal> will set the external advance mode
- <INTernal> will set the internal advance mode

MSEQuence:ADVance:SOURce?

Response

The 302 will return the EXT, or INT depending on the present multi-sequence advance source setting.

MSEQuence:DEFine <step_#>,<ssequence_#>

Purpose

This command will define multi-sequence step.

- <step_#> numeric value will define the link number
- <ssequence_#> numeric value will select the single-sequence for the above link

MSEQuence:DELete <msequence_#>

Purpose

This command will delete links within a multi-sequence table

MSEQuence:DELete:ALL

Purpose

This command will delete the entire multi-sequence table

SYSTem Subsystem

The system-related commands are not related directly to waveform generation but are an important part of operating the Model 301/302. These commands can reset or test the instrument, or query the instrument for system information.

Keyword

```
SYSTem
  :ERRor?
  :VERSion?
RESet
TEST?
*RST
*TST?
*IDN?
```

SYSTem:ERRor? (Query only command)

Purpose
This query will interrogate the 302 for programming errors.
Response to query
The 302 will return error code. Error messages are listed later in this manual.

SYSTem:VERSion? (Query only command)

Purpose
This query will interrogate the 302 for SCPI version.
Response to query
The 302 will return 1993.0.

RESet, *RST

Purpose
This command will reset the 302 to factory defaults.

TEST?, *TST? (Query only command)

Purpose
This query will invoke the 302 selftest function.
Response to query
The 302 will return “0” for no error, or error code. Codes and their associated description are listed later in this manual.

*IDN? (Query only command)

Purpose
This query will interrogate the identity of the 302.
Response to query
The 302 will return WAVETEK,301/302,0,1.0.

IEEE-STD-488.2 Common Commands and Queries

Since most instruments and devices in an ATE system use similar commands, which perform similar functions, the IEEE-STD-488.2 document has specified a common set of commands and queries, which all compatible devices must use. This avoids situations where devices from various manufacturers use different sets of commands to enable functions and report status. The IEEE-STD-488.2 treats common commands and queries as device dependent commands. For example, *TRG is sent over the bus to trigger the instrument. Some common commands and queries are optional, but most of them are mandatory.

The following is a complete listing of all common-commands and queries, which are used in the Model 301/302.

***CLS** - Clear the Status Byte summary register and all event registers.

***ESE** <enable_value> - Enable bits in the Standard Event enable register. The selected bits are then reported to the status byte.

***ESE?** - Query the Standard Event enable register. The generator returns a decimal value, which corresponds to the binary-weighted sum of all bits, set in the register.

***ESR?** - Query the Standard Event register. The generator returns a decimal value, which corresponds to the binary-weighted sum of all bits, set in the register.

***IDN?** - Query the generator's identity. The returned data is organized into four fields, separated by commas. The generator responds with its manufacturer and model number in the first two fields, and may also report its serial number and options in fields three and four. If the latter information is not available, the device must return an ASCII 0 for each. For example, Model 301/302=s response to *IDN? is:

WAVETEK,301/302,0,1.0.

***OPC** - Set the "operation complete" bit (bit 0) in the Standard Event register after the previous commands have been executed.

***OPC?** - Returns "1" to the output buffer after all the previous commands have been executed. *OPC? is used for synchronization between a controller and the instrument using the MAV bit in the Status Byte or a read of the Output Queue. The *OPC? query does not affect the OPC Event bit in the Standard Event Status Register (ESR). Reading the response to the ***OPC?** query has the advantage of removing the complication of dealing with service requests and multiple polls to the instrument. However, both the system bus and the controller handshake are in a temporary hold-off state while the controller is waiting to read the *OPC? query response.

***OPT?** - Returns the value “0” for a Model 301/302 with 4Meg memory and returns “1” for a Model 301/302 with 16Meg memory.

***RST** - Resets the generator to its default state. Default values are listed in Table 4-1.

***SRE** <enable_value> - Enables bits in the Status Byte enable register.

***SRE?** - Query the Status Byte enable register. The generator returns a decimal value in the range of 0 to 63 or 128 to 191 since bit 6 (RSQ) cannot be set. The binary-weighted sum of the number represents the value of the bits of the Service Request enable register.

***STB?** - Query the Status Byte summary register. The *STB? command is similar to a serial poll but is processed like any other instrument command. The *STB? command returns the same result as a serial poll, but the "request service" bit (bit 6) is not cleared if a serial poll has occurred.

***TRG** - Triggers the generator from the remote interface. This command effects the generator if it is first placed in the Trigger or Burst mode of operation and the trigger source is set to "BUS".

***TST?** - Implements an internal self-test and returns a value as described below. Approximately 90% of the Model 301/302 functionality is tested.

0 - Selftest passed

1 - CPU to peripherals communication failure

2 – Channel A failure

4 – Channel B failure

8 – Sequence generator failure

More than one failure can be reported at one time. For example, the returned value “17” indicates both a TBD problem and a TBD problem exist.

***WAI** – Wait for all pending operations to complete before executing any additional commands over the interface.

The SCPI Status Registers

The Model 301/302 uses the Status Byte register group and the Standard Event register group to record various instrument conditions. Figure 4-1 shows the SCPI status system.

An Event Register is a read-only register that reports defined conditions within the generator. Bits in an event register are latched. When an event bit is set, subsequent state changes are ignored. Bits in an event register are automatically cleared by a query of that register or by sending the *CLS command. The *RST command or device clear does not clear bits in an event register. Querying an event register returns a decimal value, which corresponds to the binary-weighted sum of all bits, set in the register.

An Event Register defines which bits in the corresponding event

register are logically ORed together to form a single summary bit. The user can read from and write to an Enable Register. Querying an Enable Register will not clear it. The *CLS command does not clear Enable Registers but it does clear bits in the event registers. To enable bits in an enable register, write a decimal value that corresponds to the binary-weighted sum of the bits required to enable in the register.

The Status Byte Register (STB)

The Status Byte summary register contains conditions from the other registers. Query data waiting in the generator's output buffer is immediately reported through the Message Available bit (bit 4). Bits in the summary register are not latched. Clearing an event register will clear the corresponding bits in the Status Byte summary register. Description of the various bits within the Status Byte summary register is given in the following:

Bit 0 - Decimal value 1. Not used, always set to 0.

Bit 1 - Decimal value 2. Not used, always set to 0.

Bit 2 - Decimal value 4. Not used, always set to 0.

Bit 3 - Decimal value 8. Not used, always set to 0.

Bit 4 - Decimal value 16. Message Available Queue Summary Message (MAV). The state of this bit indicates whether or not the output queue is empty. The MAV summary message is true when the output queue is not empty. This message is used to synchronize information exchange with the controller. The controller can, for example, send a query command to the device and then wait for MAV to become true. If an application program begins a read operation of the output queue without first checking for MAV, all system bus activity is held up until the device responds.

Bit 5 - Decimal value 32. Standard Event Status Bit (ESB) Summary Message. This bit indicates whether or not one or more of the enabled ESB events have occurred since the last reading or clearing of the Standard Event Status Register.

Bit 6 - Decimal value 64. Master Summary Status (MSS)/Request Service (RQS) Bit. This bit indicates if the device has at least one condition to request service. The MSS bit is not part of the IEEE-STD-488.1 status byte and will not be sent in response to a serial poll. However, the RQS bit, if set, will be sent in response to a serial poll.
Bit 7 - Decimal value 128. Not used, always set to 0.

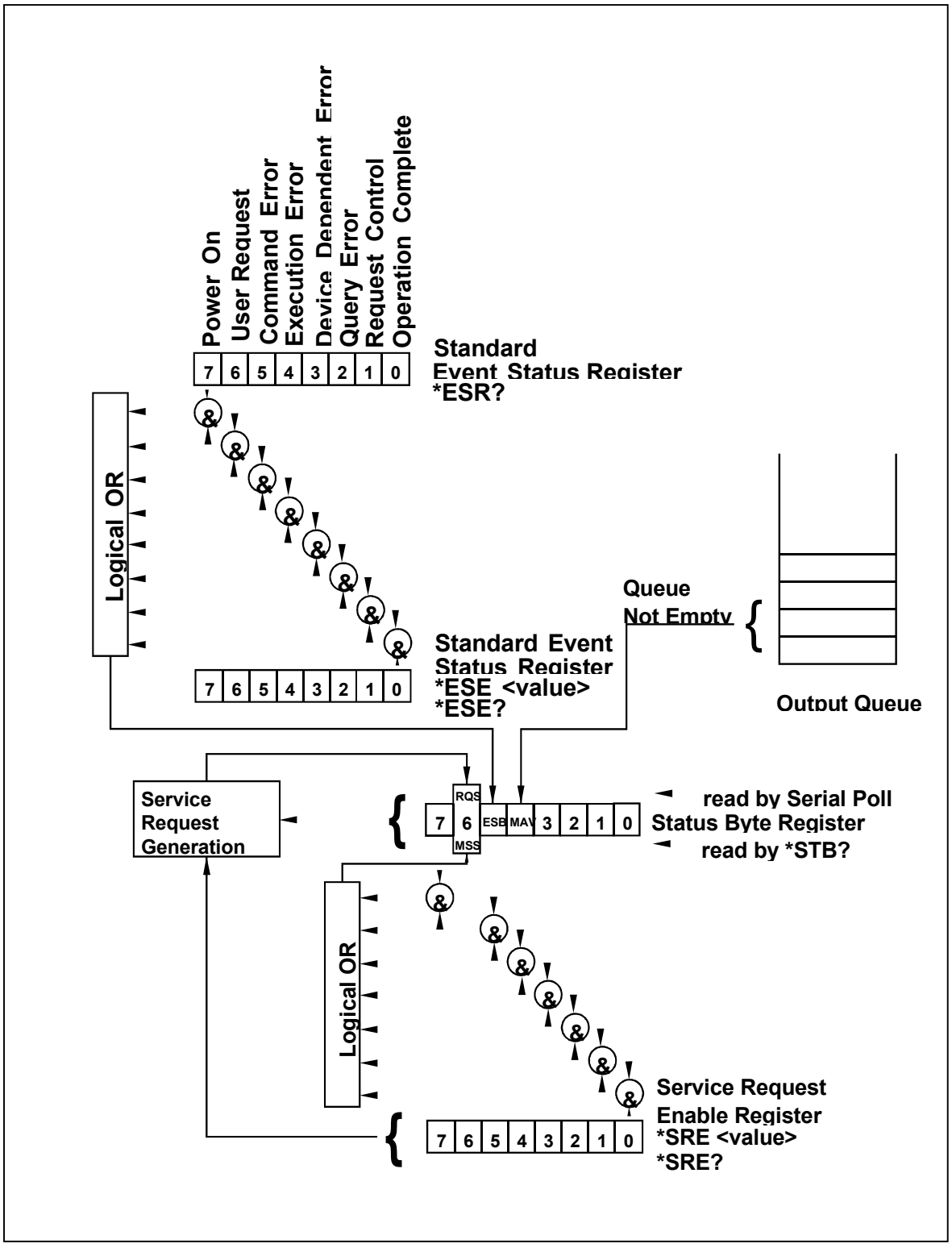

Figure 4-1 SCPI Status Registers

Reading the Status Byte Register

The Status Byte summary register can be read with the *STB? common query. The *STB? common query causes the generator to send the contents of the Status Byte register and the MSS (Master Summary Status) summary message as a single <NR1 Numeric Response Message> element. The response represents the sum of the binary-weighted values of the Status Byte Register. The *STB? common query does not alter the status byte.

Clearing the Status Byte Register

Removing the reasons for service from Auxiliary Status registers can clear the entire Status Byte register. Sending the *CLS command to the device after a SCPI command terminator and before a Query clears the Standard Event Status Register and clears the output queue of any unread messages. With the output queue empty, the MAV summary message is set to FALSE. Methods of clearing other auxiliary status registers are discussed in the following paragraphs.

Service Request Enable Register (SRE)

The Service Request enable register is an 8-bit register that enables corresponding summary messages in the Status Byte Register. Thus, the application programmer can select reasons for the generator to issue a service request by altering the contents of the Service Request Enable Register.

The Service Request Enable Register is read with the *SRE? common query. The response to this query is a number that represents the sum of the binary-weighted value of the Service Request Enable Register. The value of the unused bit 6 is always zero.

The Service Request Enable Register is written using the *SRE command followed by a decimal value representing the bit values of the Register. A bit value of 1 indicates an enabled condition. Consequently, a bit value of zero indicates a disabled condition. The Service Request Enable Register is cleared by sending *SRE0. The generator always ignores the value of bit 6. Summary of *SRE commands is given in the following.

***SRE0** - Clears all bits in the register.

***SRE1** - Not used.

***SRE2** - Not used.

***SRE4** - Not used.

***SRE8** - Not used.

***SRE16** - Service request on MAV.

***SRE32** - Service request on ESB summary bit.

***SRE128** - Not used.

Standard Event Status Register (ESR)

The Standard Event Status Register reports status for special applications. The 8 bits of the ESR have been defined by the IEEE-STD-488.2 as specific conditions, which can be monitored and reported back to the user upon request. The Standard Event Status Register is destructively read with the *ESR? common query. The Standard Event Status Register is cleared with a *CLS common command, with a power-on and when read by *ESR?.

The arrangement of the various bits within the register is firm and is required by all GPIB instruments that implement the IEEE-STD-488.2. Description of the various bits is given in the following:

Bit 0 - Operation Complete. Generated in response to the *OPC command. It indicates that the device has completed all selected and pending operations and is ready for a new command.

Bit 1 - Request Control. This bit operation is disabled on the Model 301/302.

Bit 2 - Query Error. This bit indicates that an attempt is being made to read data from the output queue when no output is either present or pending.

Bit 3 - Device Dependent Error. This bit is set when an error in a device function occurs. For example, the following command will cause a DDE error:

VOLTage 5;:VOLTage:OFFSet 2

Both of the above parameters are legal and within the specified limits, however, the generator is unable to generate such an amplitude and offset combination.

Bit 4 - Execution Error. This bit is generated if the parameter following the command is outside of the legal input range of the generator.

Bit 5 – Command Error. This bit indicates the generator received a command that was a syntax error or a command that the device does not implement.

Bit 6 - User Request. This event bit indicates that one of a set of local controls had been activated. This event bit occurs regardless of the remote or local state of the device.

Bit 7 - Power On. This bit indicates that the device's power source

was cycled since the last time the register was read.

Standard Event Status Enable Register (ESE)

The Standard Event Status Enable Register allows one or more events in the Standard Event Status Register to be reflected in the ESB summary message bit. The Standard Event Status Enable Register is an 8-bit register that enables corresponding summary messages in the Standard Event Status Register. Thus, the application programmer can select reasons for the generator to issue an ESB summary message bit by altering the contents of the ESE Register.

The Standard Event Status Enable Register is read with the *ESE? Common query. The response to this query is a number that represents the sum of the binary-weighted value of the Standard Event Status Enable Register.

The Standard Event Status Enable Register is written using the *ESE command followed by a decimal value representing the bit values of the Register. A bit value one indicates an enabled condition. Consequently, a bit value of zero indicates a disabled condition. The Standard Event Status Enable Register is cleared by setting *ESE0. Summary of *ESE messages is given in the following.

***ESE0** – No mask. Clears all bits in the register.

***ESE1** – ESB on Operation Complete.

***ESE2** – ESB on Request Control.

***ESE4** – ESB on Query Error.

***ESE8** – ESB on Device Dependent Error.

***ESE16** – ESB on Execution Error.

***ESE32** – ESB on Command Error.

***ESE64** – ESB on User Request.

***ESE128** – ESB Power on.

Error Messages

In general, whenever the Model 301/302 receives an invalid SCPI command, it automatically generates an error. Errors are stored in a special error queue and may be retrieved from this buffer one at a time. Errors are retrieved in first-in-first-out (FIFO) order. The first error returned is the first error that was stored. When you have read all errors from the queue, the generator responds with a 0,"No error" message.

If more than 30 errors have occurred, the last error stored in the

queue is replaced with -350, “Queue Overflow”. No additional errors are stored until you remove errors from the queue. If no errors have occurred when you read the error queue, the generator responds with 0,"No error".

The error queue is cleared when power has been shut off or after a *CLS command has been executed. The *RST command does not clear the error queue. Use the following command to read the error queue:

SYSTem:ERRor?

Errors have the following format (the error string may contain up to 80 characters):

-102,"Syntax error"

A complete listing of the errors that can be detected by the generator is given below.

-100,"Command error". When the generator cannot detect more specific errors, this is the generic syntax error used.

-101,"Invalid Character". A syntactic element contains a character, which is invalid for that type.

-102,"Syntax error". Invalid syntax found in the command string.

-103,"Invalid separator". An invalid separator was found in the command string. A comma may have been used instead of a colon or a semicolon. In some cases where the generator cannot detect a specific separator, it may return error -100 instead of this error.

-104,"Data type error". The parser recognized a data element different than allowed.

-108,"Parameter not allowed". More parameters were received than expected for the header.

-109,"Missing parameter". Too few parameters were received for the command. One or more parameters that were required for the command were omitted.

-128."Numeric data not allowed". A legal numeric data element was received, but the instrument does not accept one in this position.

-131,"Invalid suffix". A suffix was incorrectly specified for a numeric parameter. The suffix may have been misspelled.

-148,"Character data not allowed". A character data element was

encountered where prohibited by the instrument.

-200,"Execution error". This is the generic syntax error for the instrument when it cannot detect more specific errors. Execution error as defined in IEEE-488.2 has occurred.

-221,"Setting conflict". Two conflicting parameters were received which cannot be executed without generating an error. Listed below are events causing setting conflicts.

1. Sum of pulse or ramp parameters is more than 100. Corrective action: Change parameters to correct the problem.

2. ampl/2 + |offset| is more than 2.5. Corrective action: Reduce offset to 0, then change amplitude-offset values to correct the problem.

3. Activating filters when the 302 is set to output the built-in sine waveform, or activating the built-in sine waveform when one of the 302 filters is turned on. Corrective action: If in sine, select another function and activate the filter(s).

4. Activating burst mode when the 302 is set to sequence mode, or activating sequence mode when the 302 is set to burst mode. Corrective action: Remove the 302 from burst or sequence and then selected the desired mode.

5. An attempt to change sequence mode while the 302 is set to operate in one of the sequence modes. Corrective action: remove the 302 from sequence mode, select the required sequence type, then resume sequence operation.

6. Changing operating mode from triggered to continuous when the 302 is set to single sequence advance, or changing the operating mode from continuous to triggered when the 302 is set to automatic sequence advance mode. Corrective action: Observe the 302 advance mode while setting sequence advance.

7. In multi-sequence operation, trying to select a sequence number larger than the specified number of sequences. Corrective action: If larger number of sequences is required, exit sequence mode, select a larger number of sequences and then resume sequence operation.

8. An attempt to change the sequence number but the 302 is in single sequence mode. Corrective action: Exit sequence mode, select the multi-sequence mode, select the number of sequences you are about to use and then resume sequence operation.

-222,”Data out of range”. Parameter data, which followed a specific header, could not be used because its value is outside the valid range

defined by the generator.

-224,"Illegal parameter value". A discrete parameter was received which was not a valid choice for the command. An invalid parameter choice may have been used.

-300,"Device-specific-error". This is the generic device-dependent error for the instrument when it cannot detect more specific errors. A device- specific error as defined in IEEE-488.2 has occurred.

-311,"Memory error". Indicates that an error was detected in the instrument's memory.

-350,"Queue Overflow". The error queue is full because more than 30 errors have occurred. No additional errors are stored until the errors from the queue are removed. The error queue is cleared when power has been shut off, or after a *CLS command has been executed.

-410,"Query INTERRUPTED". A command was received which sends data to the output buffer, but the output buffer contained data from a previous command (the previous data is not overwritten). The output buffer is cleared when power is shut off or after a device clear has been executed.

Device-Specific Commands

The Model 301/302 conforms to the 1993.0 version of the SCPI standard. Some of the commands used are not included in the 1993.0 version. However, these commands are designed with the SCPI standard in mind and they follow all of the command syntax rules defined by the standard. Table 4-1 lists all device-specific commands that were designed specifically for the Model 301/302 as not confirmed SCPI 1993.0 commands.

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Appendix A SPECIFICATIONS

CONFIGURATION

Output Channels

Number of Channels	Model 301 – 1 channels; Model 302 – 2 channels (For Model 301, ignore references in the following specifications to 2nd channel)
Main	Programmable-level output channels
Auxiliary	Fixed-level, I and Q channels

SAMPLE CLOCK

Sources:

Internal	
Range	100 mSa/s to 300 MSa/s
Resolution	7 digits
Accuracy	Same as reference
Stability	Same as reference
Reference	≥0.0001% (1 ppm TCXO) initial tolerance over a 19°C to 29°C temperature range; 1ppm/°C below 19°C and above 29°C; 1ppm/year aging rate
External	From front panel BNC, 100 KHz to 300 MHz

OPERATING MODES

Normal	Continuous waveform is generated
Triggered	Each input cycle generates a single output cycle.
Internal	An internal timer repeatedly generates a single output cycle
Gated	External signal enables generator. First output cycle synchronous with the active slope of the triggering signal. Last cycle of output waveform always completed
External Burst	Preset number of up to 1M cycles stimulated by an internal, external, or manual trigger. This mode is not available in SEQ mode.

Internal Burst	An internal timer repeatedly generates a burst of up to 1M counted output cycles. This mode is not available in SEQ mode.

Trigger Sources

Internal	Internal programmable rate generator
	Period From 20 μs to 1000 s
	Accuracy ±(1% + 1 μs)
External	
Input	Front panel BNC
Frequency	15 MHz to DC
Software	IEEE 488.2 command

System Delay

Trigger to waveform output	1 Sample Clock+150 ns

STANDARD WAVEFORMS

Frequency Range	Waveform dependent
Source	Internal synthesizer

Sine

Frequency Range	100 μHz to 70 MHz, usable to 150 MHz
Band Flatness	5% to 10 MHz; 10%, to 37.5 MHz, 30% to 150 MHz
Programmable Parameters	Start phase, 0 to 360°

Triangle

Frequency Range:	100 μHz to 5 MHz, usable above 5 MHz
Adjustable Parameters	Start phase, 0 to 360°

Square

Frequency Range	100 μHz to 150 MHz
Adjustable Parameters	Duty cycle, 1% to 99%

Pulse/Ramp

Frequency Range	10 mHz to 5 MHz, usable above 5 MHz
Adjustable Parameters	
Delay	0% to 99.9% of period
Rise Time	0% to 99.9% of period

High Time	0% to 99.9% of period
Fall Time	0% to 99.9% of period

Sinc (Sine(x)/x)

Frequency Range	10 mHz to 5 MHz, usable above 5 MHz
Adjustable Parameters	
Cycles	4 to 100 cycles

Gaussian Pulse

Frequency Range	10 mHz to 5 MHz, usable above 5 MHz
Adjustable Parameters	
Time Constant	10 to 200

Exponential Decaying/Rising Pulse

Frequency Range	10 mHz to 5 MHz, usable above 5 MHz
Adjustable Parameters	
Time Constant	-100 to 100

DC

Range	-100% to 100% of amplitude

ARBITRARY WAVEFORMS

Waveform Memory	4 Meg points standard, 16 Meg points optional
Memory Segmentation	
Number of Segments	1 to 4096
Min Segment Size	16 points
Memory Interleave	8 (All trace lengths must be multiples of 8)
Vertical Resolution	12 bits (4096 points)

SINEWAVE TOTAL HARMONIC DISTORTION

(at 4096 vertical points and sampling rate of 300 MHz)	0.5%
Harmonic Signals Below the Carrier Level (at 4096 vertical points)	>50 dBc to 1 MHz >40 dBc to 37.5 MHz >30 dBc to 70 MHz >28 dBc to 150 MHz

SEQUENCED ARBITRARY WAVEFORMS

Operation	Permits division of the memory bank into smaller segments. Segments may be linked, and repeated in user-selectable fashion to generate extremely long waveforms.
Advance Modes	
Automatic Sequence Advance	No triggers required to step from one segment to the next. Sequence is repeated continuously through a pre-programmed sequence table
Stepped Sequence Advance	Current segment is sampled continuously, external trigger advances to next programmed segment. Control input is TRIG IN connector.
Single Sequence Advance	Current segment is sampled to the end of the segment and idles there. Next trigger advances to next segment. Control input is TRIG IN connector.
Advance Source	
Internal	Internal programmable rate generator
Period	From 20 μs to 1000 s
Accuracy	±(1% + 1 μs)
External	
Input	Front panel Trigger input
Frequency	15 MHz to DC
Software	IEEE 488.2 command
Sequencer steps	From 1 to 4096
Segment loops	From 1 to 1 Meg
Segment Duration	Minimum 1 μs for more than one loop.

SEQUENCED SEQUENCES

Operation	Number of sequences may be linked in a multi-sequence table to generate extremely long sequences.
Number of Sequenced Sequences	16
Segment Limitation Per Sequence	2 sequences, 2048 segments; 4 sequences, 1024 segments; 8 sequences, 512 segments; 16 sequences, 256 segments
Advance Modes	
Selectable	GPIB or RS232 command selects an active sequence
Stepped	Current sequence is sampled continuously, external

	trigger advances to next programmed sequence. Control input is TRIG IN connector.
Advance Source	
Internal	Internal programmable rate generator
Period	From 20 μs to 1000 s
Accuracy	±(1% + 1 μs)
External	
Input	Front panel Trigger input
Frequency	15 MHz to DC
Software	IEEE 488.2 command

OUTPUTS (CHANNELS A & B)

Connector	Front panel BNC
Stand-by	Output Off or Normal
Impedance	50Ω, ±1%
Protection	Protected against temporary short to case ground
Glitch Energy	100 pV-s at 5 Vp-p
Amplitude	
Range	10 mV to 5 Vp-p, into 50Ω
Resolution	3.5 digits
Accuracy (1 KHz)	±(1% + 25 mV), 1.000 V to 5 Vp-p
	±(1% + 5 mV), 100 mV to 999.9 mVp-p
	±(1% + 2 mV), 10 mV to 99.99 mVp-p
Offset	
Range	0 to ±2.495 V
Resolution	5 mV
Accuracy	±(2%+10 mV)
Filters	150 MHz, Elliptic 7 pole - standard
	70 MHz, Elliptic 7 pole - standard
	5 MHz - available upon request
	2.5 MHz - available upon request
	800 KHz - available upon request
Square Wave, Pulse	
Rise/Fall time	<2.5 ns, 10% to 90% of amplitude
Aberration	<5%

Inter-Channel Control

Phase Offset

Range in Degrees	0 to 360°
Range in Waveform Points	0 to waveform length
Range Setting Resolution	
Coarse	8 points
Fine	1 point to 128 k points, 8 points above 128 k.
Accuracy	±[Resolution + (3/wave_period) x 360], (wave_period in ns)
Initial Skew	<±2 ns

Inter-Channel Dependency

Separate control	Amplitude, offset, standard waveforms, user waveforms, amplitude modulation
Common Control	Sample clock, frequency, trigger modes, user waveform size, user waveform divider, sequence table, SYNC output

Auxiliary Outputs (I & Q)

AUX Output

Operation	Outputs the same waveform as the Main output.
Connector	Front panel BNC
Impedance	50Ω, ±1%
Level	1 V typical into 50Ω
Protection	Protected against temporary short to case ground

SYNC Output

Connector	Front panel BNC
Stand-by	SYNC Off or Normal
Impedance	50Ω, ±1%
Level	>2 V into 50Ω, 4V nominal into 10KΩ
Protection	Protected against temporary short to case ground
Validators	BIT, LCOM, PULSE
Position	Point 0 to n, programmable
Width Control	From 1% to 99%, programmable when placed in Pulse validator mode

INPUTS

Amplitude Modulation (AM)

Modulation Input	Front panel BNC
Impedance	1 M, ±5%
Max Input Voltage	±12 V
Sensitivity	0 V to -2 V (2 Vp-p) produce 100% modulation
	0 V to -4 V (4 Vp-p) produce 200% modulation
Source	External
Modulation Range	0 to 200%
Bandwidth	DC to 1 MHz

TRIG Input

Connector	Front panel BNC
Impedance	10 KΩ, ±5%
Threshold Range	Programmable from -10 V to + 10 V
Threshold Resolution	50 mV
Sensitivity	0.2 Vp-p
Max Input Voltage	10 Vrms, 1 KHz to DC; ±12 V dc above 1 KHz
Min Pulse Width	20 ns
Slope	Positive or negative going edge, programmable

External Sample Clock Input

Connector	Front panel BNC
Impedance	50 Ω, AC coupled
Range	100KHz to 300 MHz
Sensitivity	200 mV rms

GENERAL

GPIB Information

GPIB Revision	IEEE-488.2
SCPI Revision	1993.0
Model Code	301/302
Logical Address Settings	1 - 31, configured via internal DIP switch
DMA	A32, D16, 4 Meg points. Expandable to 16 Meg points. Note: 1 point = 2 bytes

RS232 Information

Connector	Rear panel 9-pin D type, male
Protocol	SCPI + checksum
SCPI Revision	1993.0

Front Panel Indicator LED's

Power On	Green – Mains power on
Output On	Green - Output on / off (Separate for each channel)
Access	Yellow - Module addressed on VXIbus
Remote	Red – GPIB remote command

Power Requirements

Mains Input	85 V to 265 VAC, 48-63 Hz
Maximum Total Module Power	<150 W

Self Test Fault Coverage

Hardware Method	Internal relay wraps main output back to fault detection circuitry
Fault Coverage (%)	90%

EMC and Safety Certification

CE marked

Mechanical

Dimensions	19” x 5.25” x 16” (W x H x D)
Weight	9 Kg

Environmental

Operating temperature	0 °C - 50 °C
Humidity (non-condensing)	11 °C - 30 °C 95% +5%
	31 °C - 40 °C 75% +5%
	41 °C - 50 °C 45% +5%